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# CONCRETE
# DESIGNERS' MANUAL

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# CONCRETE DESIGNERS' MANUAL

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### *TABLES AND DIAGRAMS FOR THE DESIGN OF REINFORCED CONCRETE STRUCTURES*

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# PREFACE

The tables and diagrams presented in this manual make possible the rapid designing of reinforced concrete structures in accordance with the Joint Committee Recommendations, the American Concrete Institute Recommendations, the New York Building Code Requirements and the Chicago Building Code Requirements. Some of these tables and diagrams will also be found of such a general nature that they can be used when the designing requirements are different from any of those mentioned. No tables are presented based on the flat slab recommendations of the Joint Committee as these recommendations are so conservative that they are not used to any extent.

The authors have for some time been preparing and using in their practice various tables and diagrams in order to finally obtain complete data in the most convenient form and of the greatest value to the majority of designing engineers. The collection given in this book is the result.

No attempt has been made to develop theory or to duplicate information not directly relating to concrete design which can conveniently be found in other handbooks possessed by all designers.

G. A. H.
C. S. W.

*April*, 1921.

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# CONCRETE
# DESIGNERS' MANUAL

## FLEXURE FORMULAS USED IN PREPARING TABLES AND DIAGRAMS

The flexure formulas made standard by the Joint Committee relate to working stresses and safe loads, and are based on the straight-line theory of stress distribution. These formulas were used in preparing the tables and diagrams in this book.

### STANDARD NOTATION

**Rectangular Beams.**

$f_s$ = tensile unit stress in steel.
$f_c$ = compressive unit stress in concrete.
$E_s$ = modulus of elasticity of steel.
$E_c$ = modulus of elasticity of concrete.
$n = \frac{E_s}{E_c}$
$M$ = moment of resistance, or bending moment in general.
$A_s$ = steel area.
$b$ = breadth of beam.
$d$ = depth of beam to center of steel.
$k$ = ratio of depth of neutral axis to depth $d$.
$z$ = depth below top to resultant of the compressive stresses.
$j$ = ratio of lever arm of resisting couple to depth $d$.
$jd = d - z$ = arm of resisting couple.
$p$ = steel ratio $= \frac{A_s}{bd}$.

**T-Beams.**

$b$ = width of flange.
$b'$ = width of stem.
$t$ = thickness of flange.

**Beams Reinforced for Compression.**

$A'$ = area of compressive steel.
$p'$ = steel ratio for compressive steel.
$f_s'$ = compressive unit stress in steel.
$C$ = total compressive stress in concrete.
$C'$ = total compressive stress in steel
$d'$ = depth to center of compressive steel.
$z$ = depth to resultant of $C$ and $C'$.

**Shear, Bond and Web Reinforcement.**

$V$ = total shear.
$V'$ = total shear producing stress in reinforcement.
$v$ = shearing unit stress.

$u$ = bond stress per unit area of bar.
$o$ = circumference or perimeter of bar.
$\Sigma_0$ = sum of the perimeters of all bars.
$T$ = total stress in single reinforcing member.
$s$ = Horizontal spacing of reinforcing members.
$A_v$ = area of shear steel in section of beam considered (A. C. I. notation).
$f_v$ = tensile stress in web reinforcement (A. C. I. notation).
$a$ = spacing of shear steel measured perpendicular to its direction (A. C. I. notation).

**Columns.**

$A$ = total net area.
$A_s$ = area of longitudinal steel.
$A_c$ = area of concrete.
$P$ = total safe load.

## FORMULAS

**Rectangular Beams.**

$$k = \sqrt{2pn + (pn)^2} - pn = \frac{1}{1 + \frac{f_s}{nf_c}} = \frac{nf_c}{nf_c + f_s}$$

$$j = 1 - \tfrac{1}{3}k$$

$$p = \frac{A_s}{bd} = \frac{\tfrac{1}{2}}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c} + 1\right)} = \frac{f_c k}{2f_s}$$

$$M_c = \tfrac{1}{2}f_c kj(bd^2), \quad \text{or} \quad bd^2 = \frac{2M}{f_c kj}, \quad \text{or} \quad f_c = \frac{2M}{kjbd^2}$$

$$M_s = pf_s j(bd^2), \quad \text{or} \quad bd^2 = \frac{M}{pf_s j}, \quad \text{or} \quad f_s = \frac{M}{A_s jd}$$

$$f_c = \frac{2f_s p}{k} \quad \text{or} \quad \frac{f_s k}{n(1 - k)}$$

**T-Beams.**—With a T-beam it is necessary to distinguish two cases; namely, (1) the neutral axis in the flange, and (2) the neutral axis in the web.

*Case I. The Neutral Axis in the Flange.*—All formulas for "moment calculations" of rectangular beams apply to this case. It should be remembered, however, that $b$ of the formulas denotes flange width, not web width, and $p$ (the steel ratio) is $\frac{A_s}{bd}$, not $\frac{A_s}{b'd}$.

*Case II. The Neutral Axis in the Web.*—The amount of compression in the web is commonly small compared with that in the flange, and is generally neglected. The formulas to use, assuming a straight-line variation of stress and neglecting the compression in the web, are:

$$k = \frac{1}{1 + \frac{f_s}{nf_c}}$$

$$kd = \frac{2ndA_s + bt^2}{2nA_s + 2bt}$$

$$k = \frac{pn + \tfrac{1}{2}\left(\frac{t}{d}\right)^2}{pn + \frac{t}{d}}$$

$$z = \frac{3kd - 2t}{2kd - t} \cdot \frac{t}{3}$$

$$jd = d - z$$

$$j = \frac{6 - 6\left(\frac{t}{d}\right) + 2\left(\frac{t}{d}\right)^2 + \left(\frac{t}{d}\right)^3\left(\frac{1}{2pn}\right)}{6 - 3\frac{t}{d}}$$

$$f_s = \frac{M}{A_s jd} = \frac{M}{pjbd^2}$$

$$f_c = \frac{f_s k}{n(1 - k)}$$

$$f_s = \frac{f_c n(1 - k)}{k}$$

$$M_s = f_s A_s jd$$

$$M_c = f_c\left(1 - \frac{t}{2kd}\right) bt \cdot jd$$

Approximate formulas can also be obtained. The arm of the resisting couple is never as small as $d - \frac{1}{2}t$, and the average unit compressive stress is never as small as $\frac{1}{2}f_c$, except when the neutral axis is at the top of the web. Using these limiting values as approximations for the true ones,

$$M_c = \tfrac{1}{2}f_c bt(d - \tfrac{1}{2}t)$$

$$M_s = A_s f_s(d - \tfrac{1}{2}t), \text{ or } A_s = \frac{M}{f_s(d - \frac{1}{2}t)}$$

The errors involved in these approximations are on the side of safety.

Formulas which take into account the compression in the stem are recommended where the flange is small compared to the stem. Such formulas may be found in the report of the Joint Committee, and are as follows:

$$kd = \sqrt{\frac{2ndA_s + (b - b')t^2}{b'} + \left(\frac{nA_s + (b - b')t}{b'}\right)^2} - \frac{nA_s + (b - b')t}{b'}$$

$$z = \frac{(kdt^2 - \frac{2}{3}t^3)b + [(kd - t)^2(t + \frac{1}{3}(kd - t))]b'}{t(2kd - t)b + (kd - t)^2 b'}$$

$$jd = d - z$$

$$f_s = \frac{M}{A_s jd}$$

$$f_c = \frac{2Mkd}{[(2kd - t)bt + (kd - t)^2 b']jd}$$

**Rectangular Beams Reinforced for Compression.**

$$k = \sqrt{2n\left(p + p'\frac{d'}{d}\right) + n^2(p + p')^2} - n(p + p')$$

$$k = \frac{1}{1 + \frac{f_s}{nf_c}}$$

$$j = \frac{k^2\left(1 - \frac{1}{3}k\right) + 2p'n\left(k - \frac{d'}{d}\right)\left(1 - \frac{d'}{d}\right)}{k^2 + 2p'n\left(k - \frac{d'}{d}\right)}$$

$$f_s = \frac{M}{A_s jd} = \frac{M}{pjbd^2}$$

$$f_c = \frac{f_s k}{n(1 - k)}$$

$$f'_s = f_s \frac{k - \frac{d'}{d}}{1 - k}$$

$$f_s = \frac{f_c n(1 - k)}{k}$$

$$M_s = bd^2 f_s pj$$

$$d = \frac{M}{A_s f_s j}$$

**Shear, Bond and Web Reinforcement.**

$$v = \frac{V}{bjd}$$

$$u = \frac{V}{\Sigma ojd}$$

*Joint Committee* (Recommended $V' = \frac{2}{3}V$):

Vertical web reinforcement

$$s = \frac{A_s f_s jd}{V'} = \frac{Tjd}{V'} \text{ or } T = \frac{V's}{jd} \qquad \text{(a)}$$

Bars bent up at angles between 20 and 45 deg. with the horizontal, and web members inclined at 45 deg.

$$s = \frac{A_s f_s jd}{0.75V'} = \frac{Tjd}{0.75V'} \text{ or } T = \frac{3}{4}\,\frac{V's}{jd} \qquad \text{(b)}$$

*American Concrete Institute:*

$$a = \frac{A_v f_v jd}{V'} \text{ or } A_v = \frac{V'a}{f_v jd}$$

**Columns.**

*Square Cored*

$P = Af_c[1 + (n - 1)p]$

*Round Cored Hooped*

$P = Af_c[1 + (n - 1)p]$..................Joint Committee

$P = Af_c[(1 + 4np') + (n - 1)p]$..........Am. Conc. Inst.

$P = Af_c[1 + (n - 1)p] + 2f_s p'A$..........New York Code

$P = Af_c(1 + 2.5np')[1 + (n - 1)p]$.......Chicago Code

(In the above formulas $p'$ = percentage of spiral. $f_s$ in the New York formula is taken at 20,000 lb. per sq. in.)

## SECTION 1

## SLABS

Diagrams 1 to 9 inclusive give the total safe loads on solid slabs of different depths for the various combinations of working stresses, bending moment coefficients and span lengths.

Diagrams 10 and 11 give the bending moments for different values of the total load per square foot, the span length, and the bending moment coefficients.

Diagrams 12 to 17 inclusive may be used to find the moments of resistance and area of steel required in solid slabs for various combinations of working stresses.

Table 1 may be employed to find the size and spacing of round or square rods for a given sectional area of steel per foot of solid slab.

Tables 2 to 7 inclusive give the total safe load for ribbed slabs for various combinations of working stresses.

### Example of Design of Solid Slab

*Given: Live load* = 300 *lb. per sq. ft.; span length* = 8 *ft.* 6 *in.*; $M = \frac{wl^2}{12}$; $f_c = 650$; $f_s = 16{,}000$; $n = 15$.

Using Diagram 3, a slab of 8½-ft. span, with a depth to steel of 4¾ in., is found to have sufficient strength to carry a total load of 405 lb. per sq. ft. Assuming a 5½-in. rough slab with 1 in. of finish on top (not placed monolithically) and plastered below, the loading will be as follows:

| | |
|---|---|
| 6½ in. of concrete | = 81 |
| Plaster. . . . . . . . . . . | = 5 |
| Live load. . . . . . . . . | = 300 |
| Total load | = 386 lb. per sq. ft. |

Diagram 11 shows the bending moment for this load on an 8½-ft. span, when $M = \frac{wl^2}{12}$, to be 27,900 in.-lb

Entering Diagram 12 at the left with this bending moment, it is found that the area of steel required per foot width for a slab having a depth to steel of 4¾ in. is 0.42 sq. in., or ½-in. round rods spaced 5½ in. on centers (see also Table 1).

The use of the bending moment coefficient $\frac{1}{12}$ means that the slab is continuous over supports and that the area of steel over the supports must be the same as at the center of the span. From Diagram 25, page 57, it will be found that one-half of the rods can be bent up from the bottom at 22 in. from the support and these rods should be run to the quarter point of the adjacent span.

### Example of Design of Ribbed Slab

*Given: Live load* = 100 *lb. per sq.ft.; hollow-tile floor; span of joists* = 19 *ft.*; $M = \frac{wl^2}{10}$; $f_c = 650$; $f_s = 16{,}000$; $n = 15$.

Assuming a 2-in. topping and an 8-in. tile, Table 2 shows the total safe load to be 190 lb. per sq. ft., with a steel area per joist of 0.90 sq. in. The table also shows the dead weight of floor to be 73 lb. per sq. ft. which makes a total load to be carried of 173 lb. per sq. ft., or less than the maximum safe load. The floor is usually plastered below, which would make the total load 178 lb. per sq. ft. A 3½-in. topping with 6-in. tile would also answer.

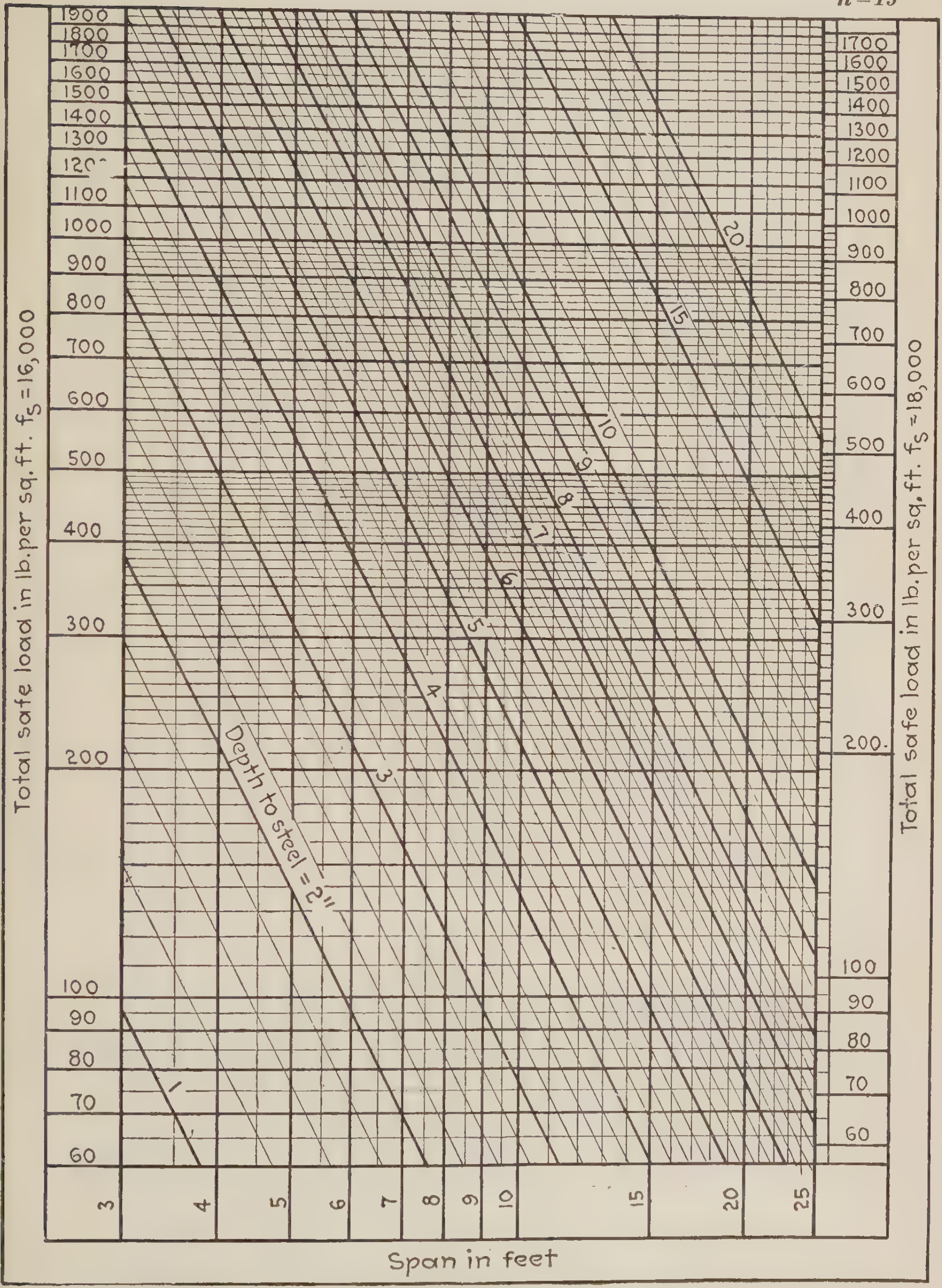
When the size of tile and thickness of topping have been determined, it is necessary to design the joists with reference to shear, bond, and compression in the concrete at the haunch by treating them as individual beams.

DIAGRAM 1

## SAFE LOAD ON SOLID CONCRETE SLABS

$$M = \frac{wl^2}{8}$$

$f_c = 650$
$f_s = 16,000$
$f_s = 18,000$
$n = 15$

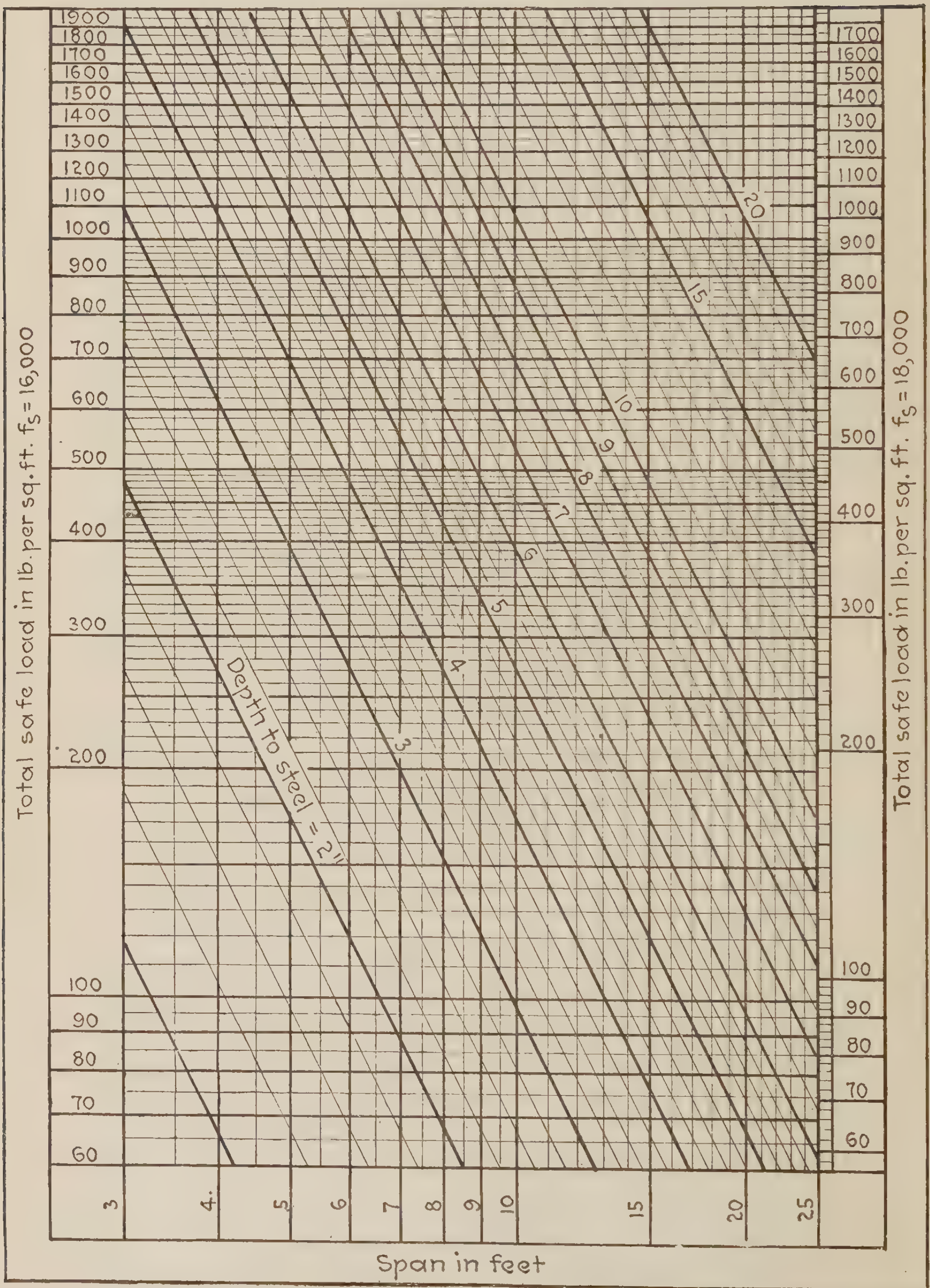


**SOLID SLABS**

$f_c = 650$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$

## SAFE LOAD ON SOLID CONCRETE SLABS

$$M = \frac{wl^2}{10}$$

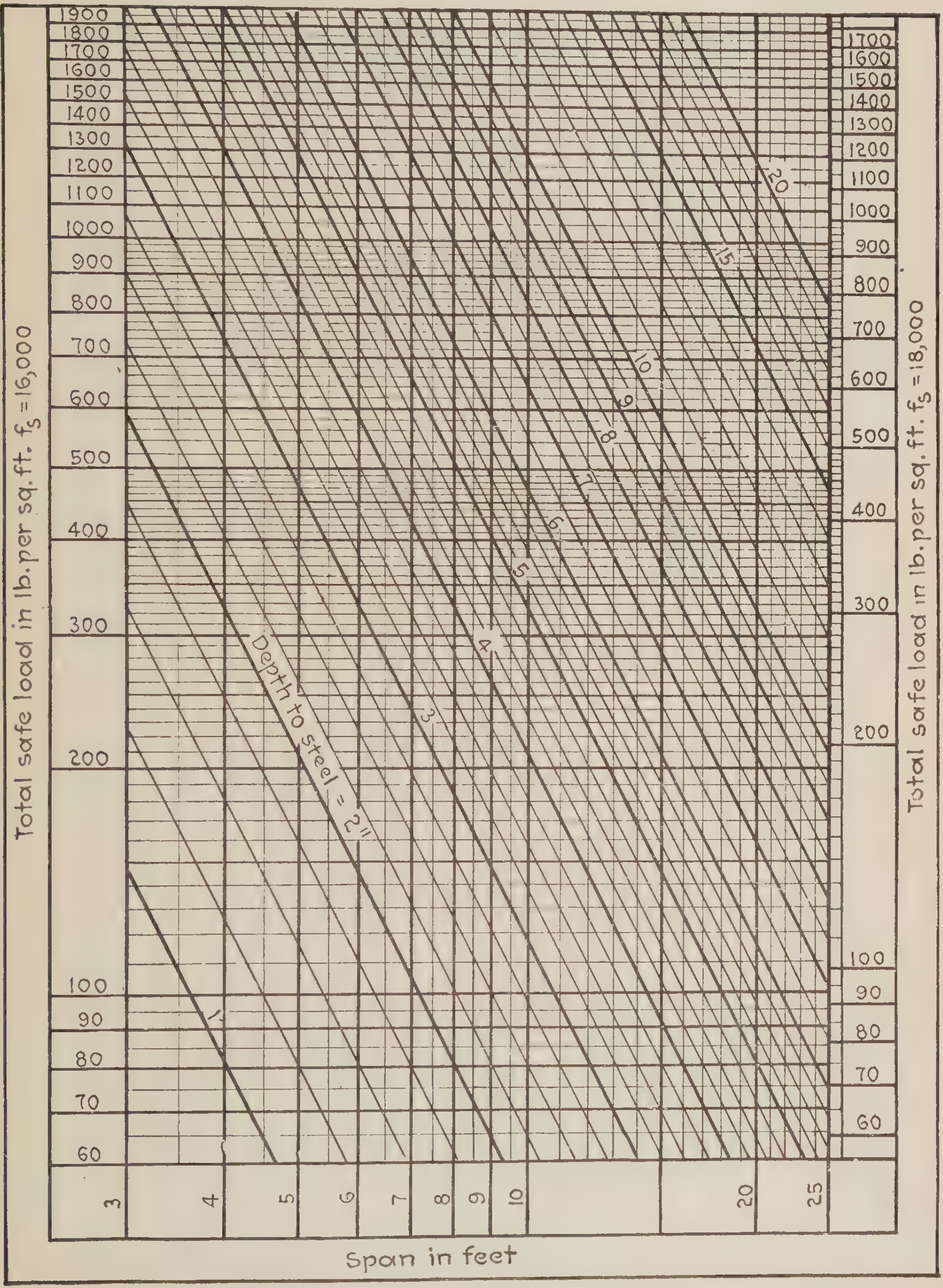


**SOLID SLABS**

# SAFE LOAD ON SOLID CONCRETE SLABS

$$M = \frac{wl^2}{12}$$

$f_c = 650$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$



**SOLID SLABS**

$f_c = 700$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$

## SAFE LOAD ON SOLID CONCRETE SLABS

$$M = \frac{wl^2}{8}$$

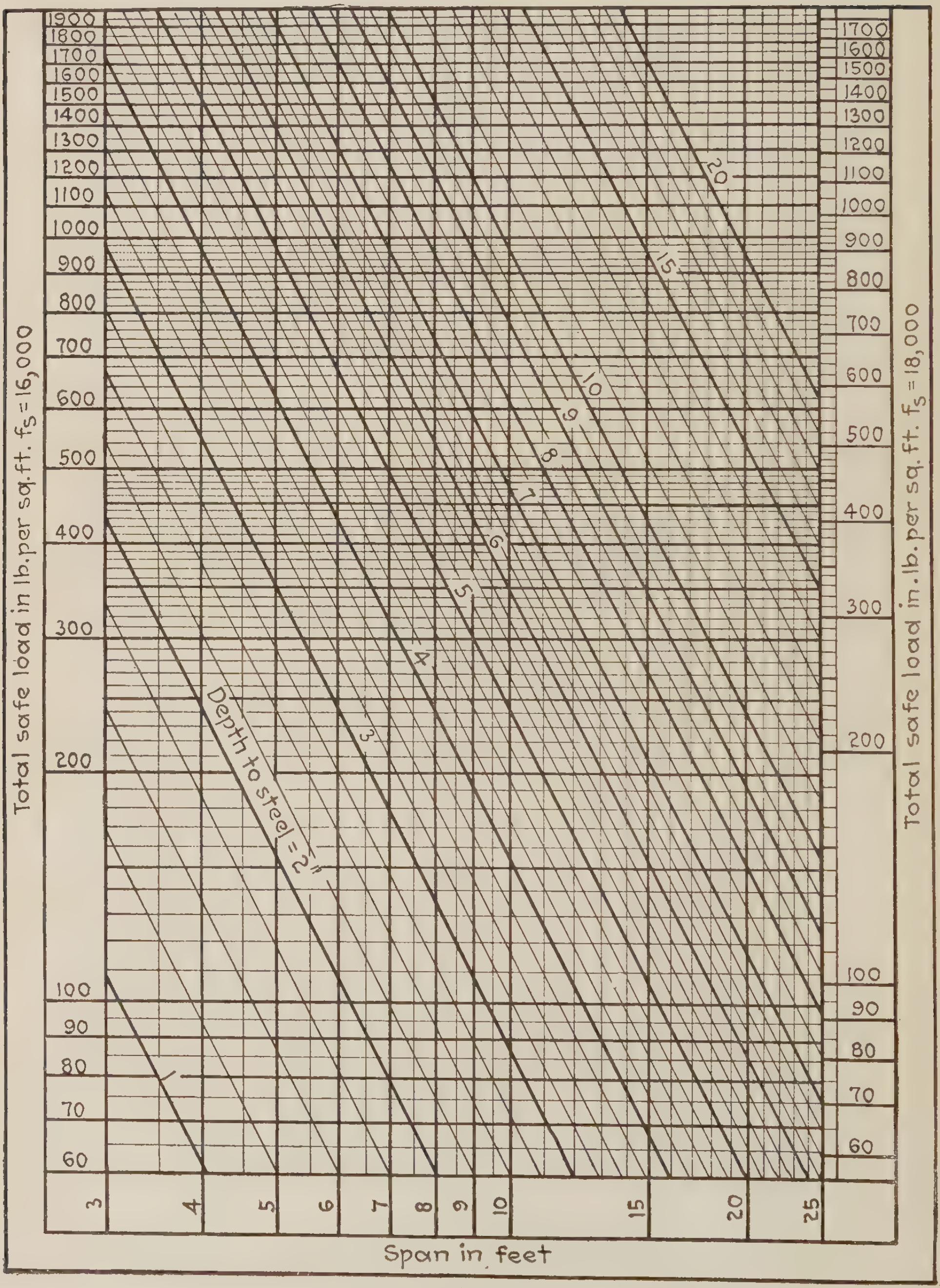
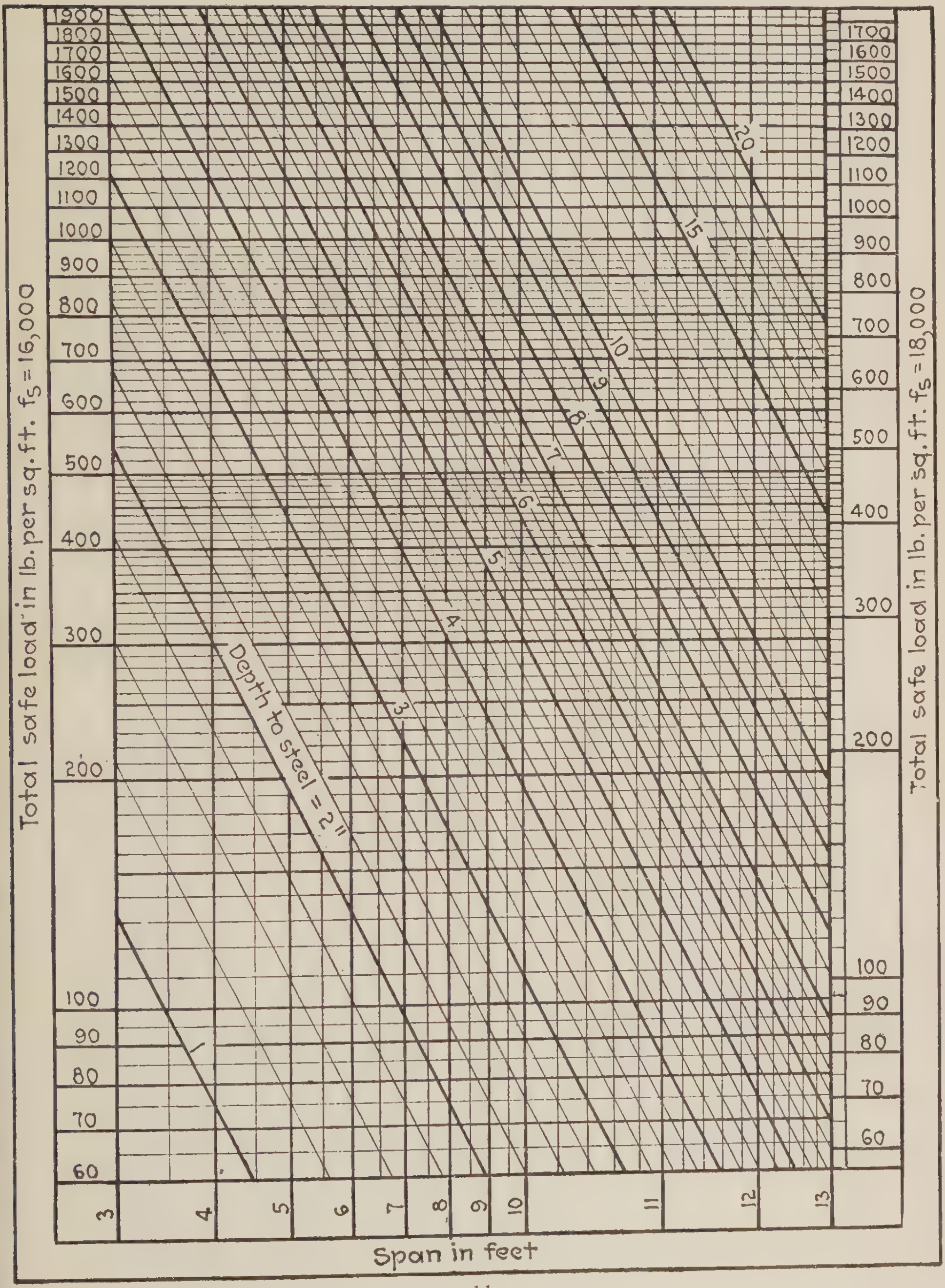


DIAGRAM 5

## SAFE LOAD ON SOLID CONCRETE SLABS

$$M = \frac{wl^2}{10}$$

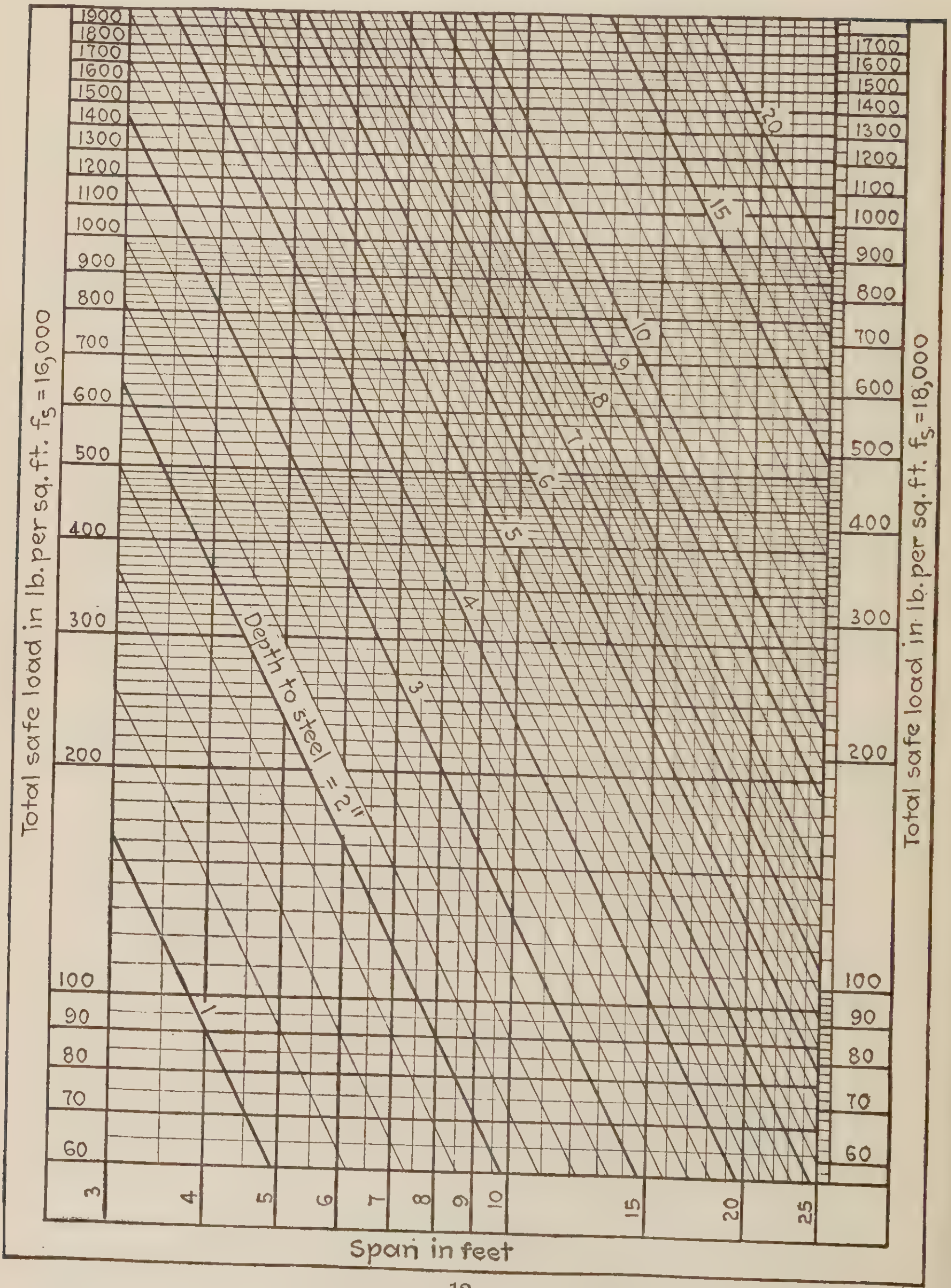
$f_c = 700$
$f_s = 16,000$
$f_s = 18,000$
$n = 15$



$f_c = 700$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$

## SAFE LOAD ON SOLID CONCRETE SLABS

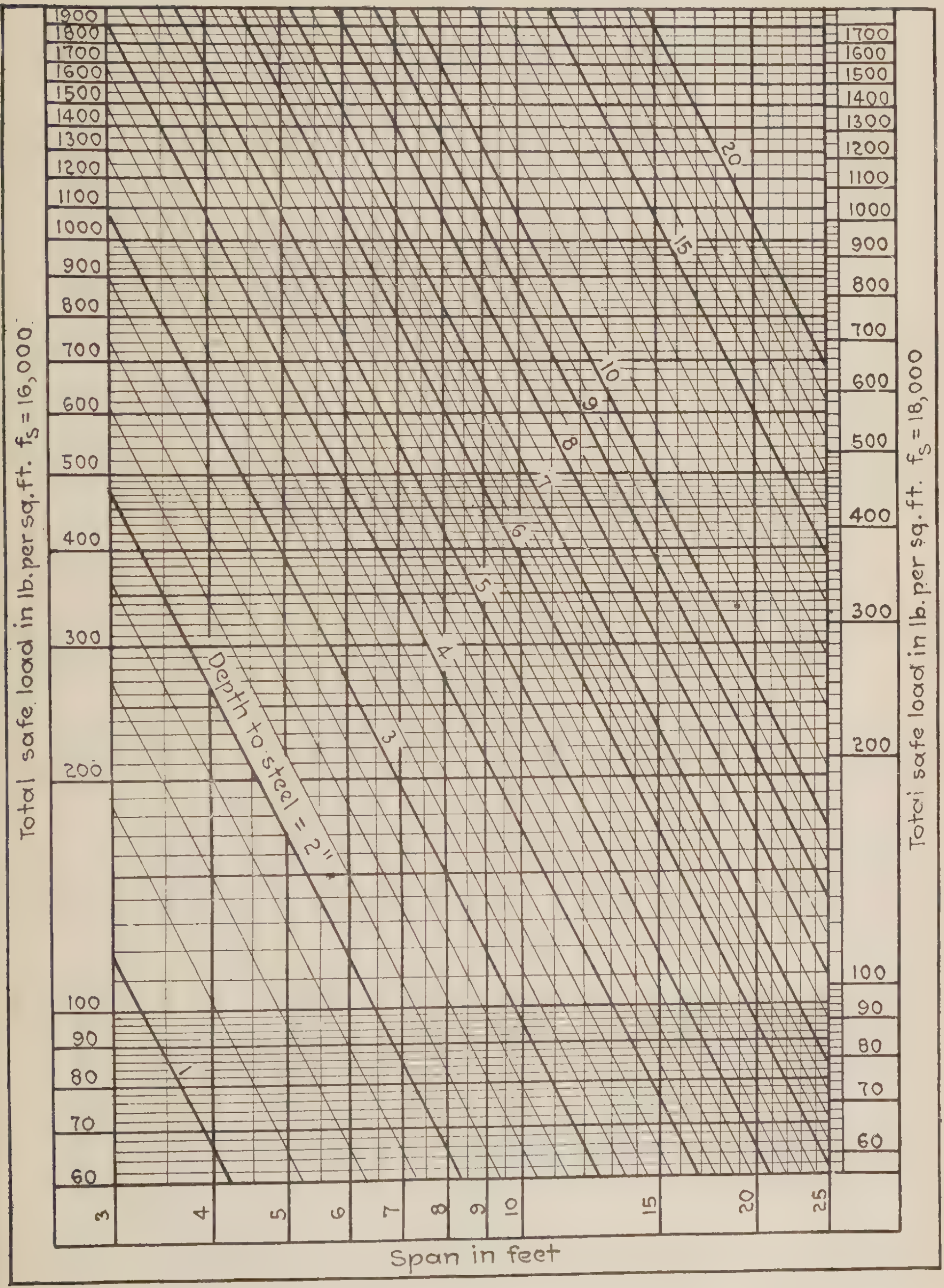
$$M = \frac{wl^2}{12}$$



## SAFE LOAD ON SOLID CONCRETE SLABS

$$M = \frac{wl^2}{8}$$

$f_c = 750$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$



$f_c = 750$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$

## SAFE LOAD ON SOLID CONCRETE SLABS

$$M = \frac{wl^2}{10}$$

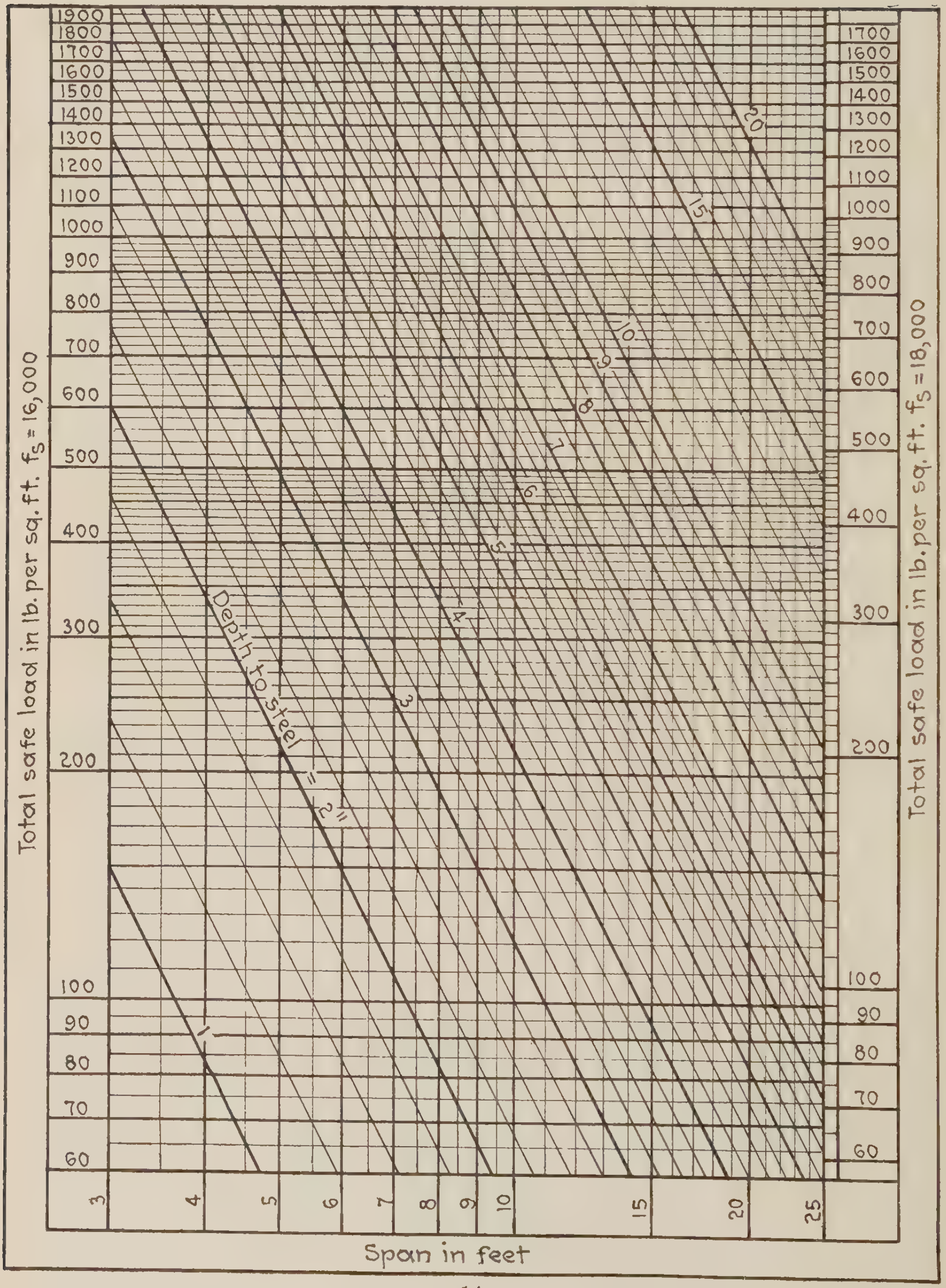
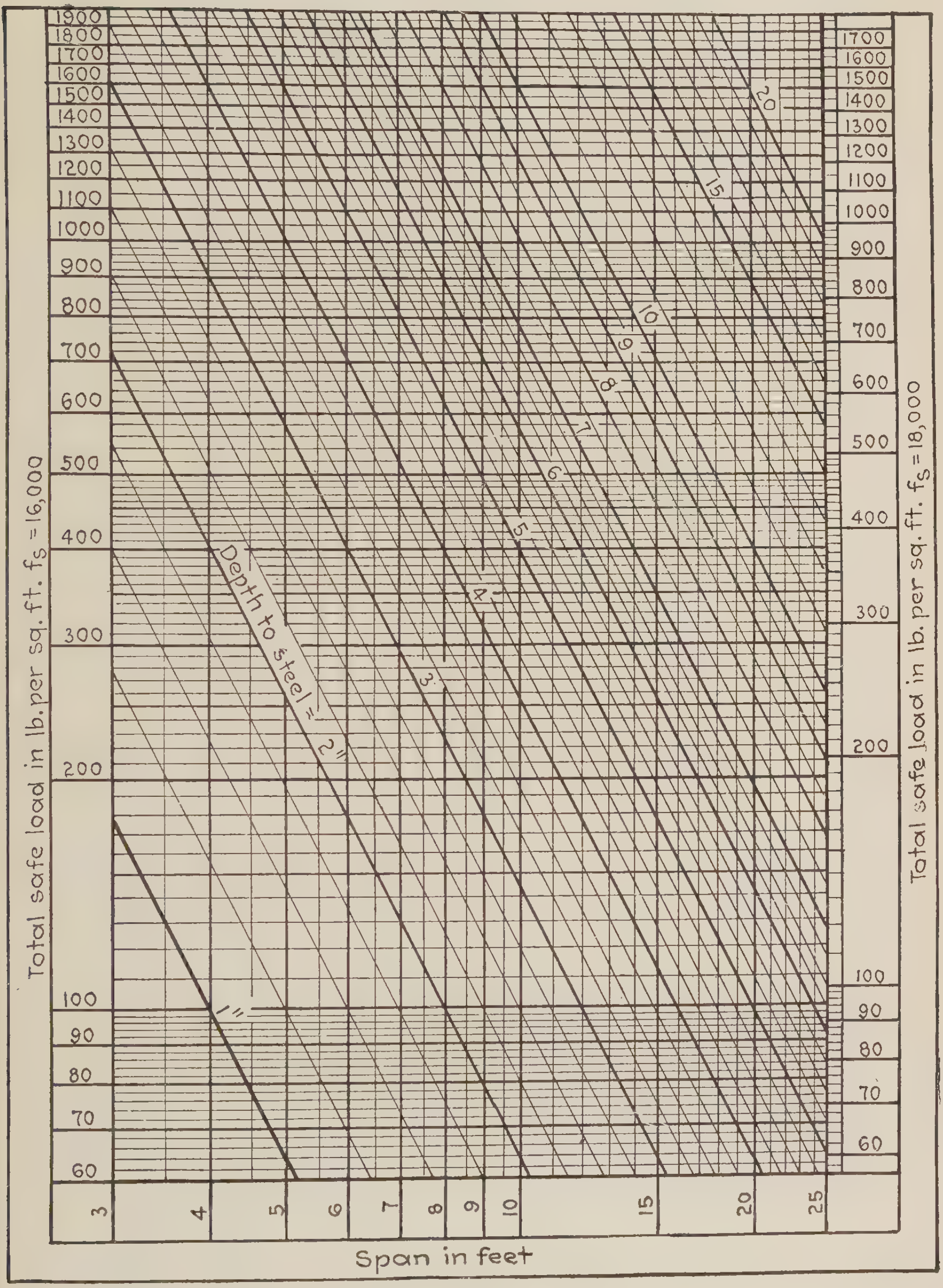


DIAGRAM 9

## SAFE LOAD ON SOLID CONCRETE SLABS

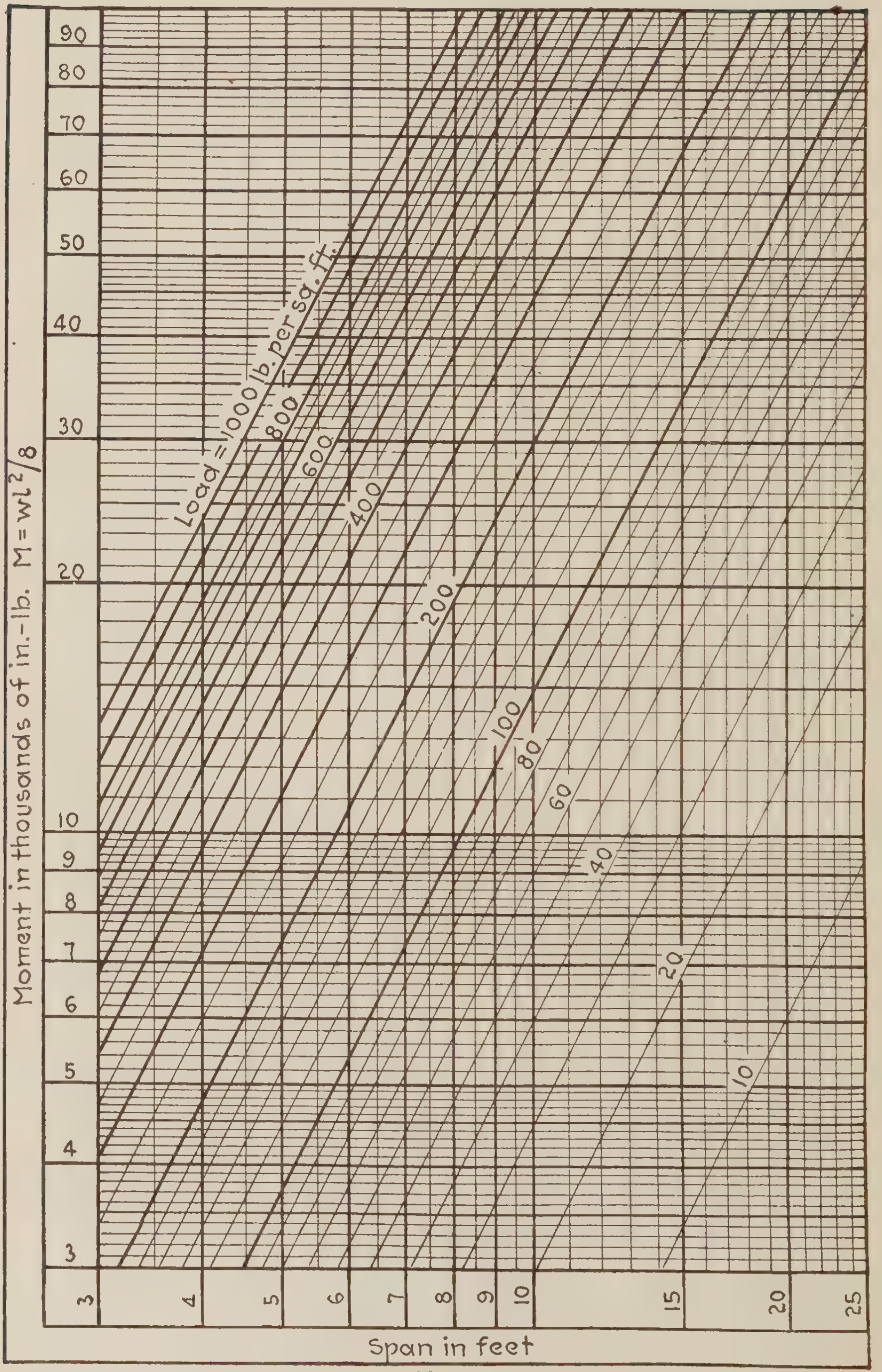
$$M = \frac{wl^2}{12}$$

$f_c = 750$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$



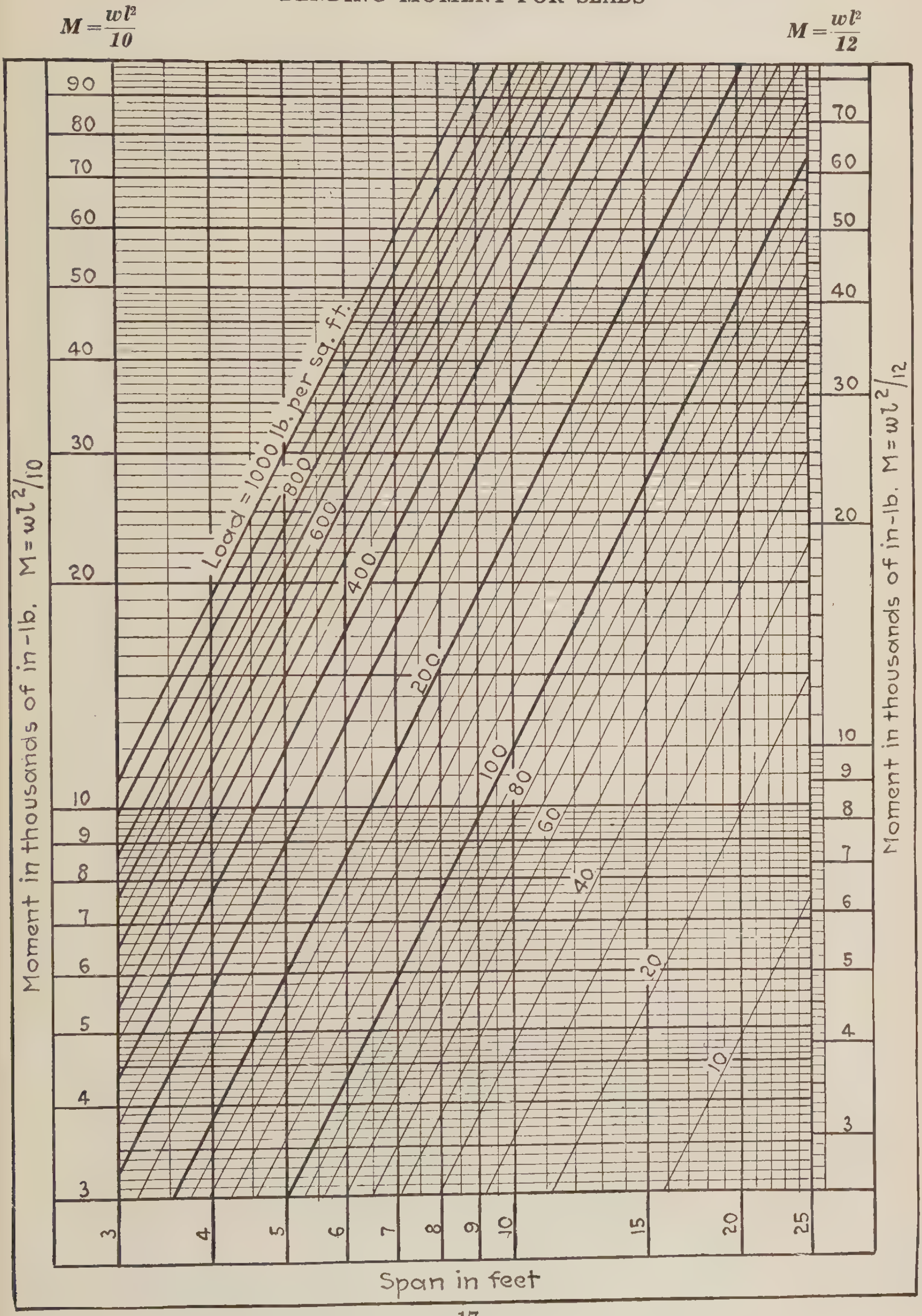
## BENDING MOMENT FOR SLABS

$$M = \frac{wl^2}{8}$$



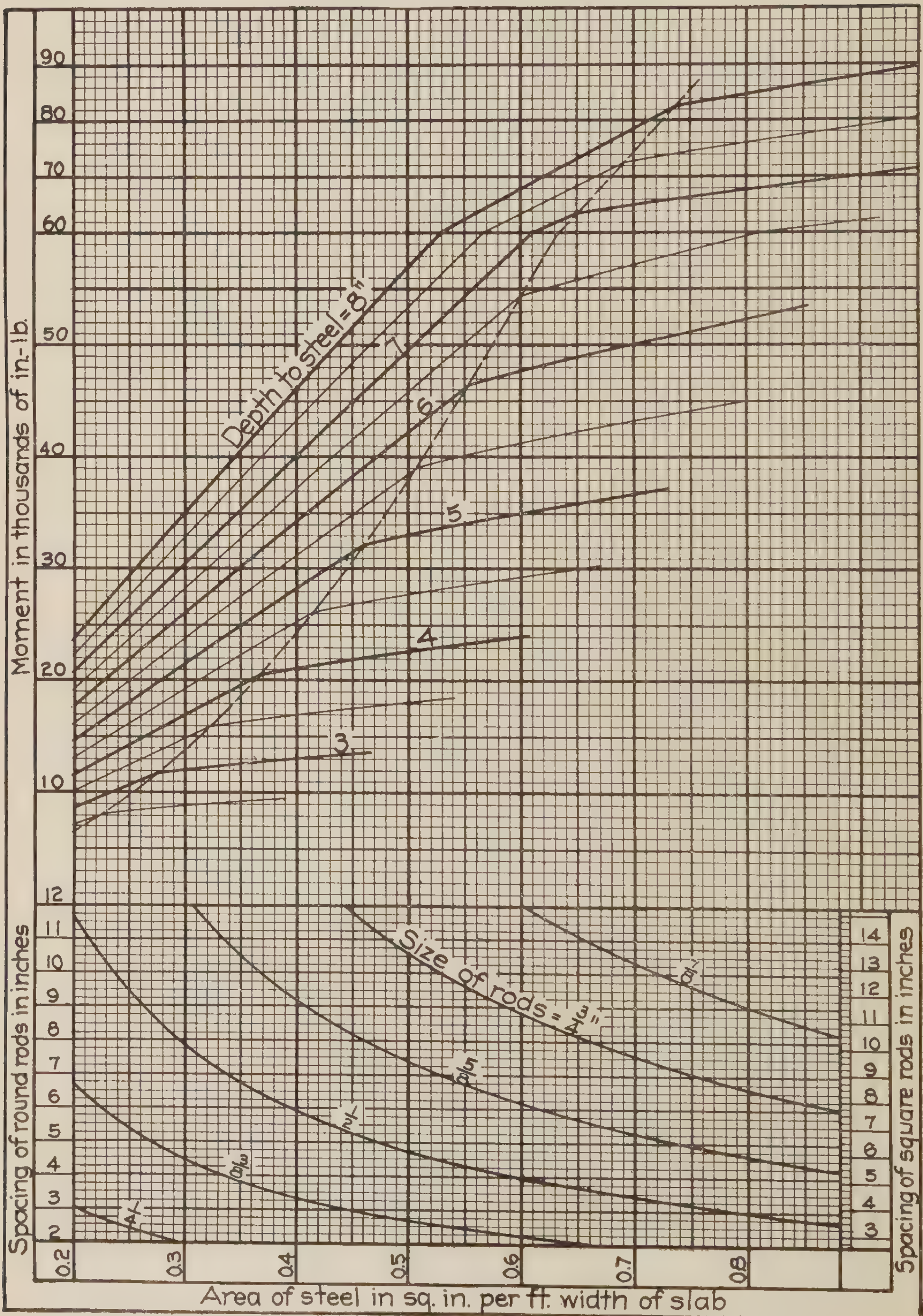
**SOLID SLABS**

## BENDING MOMENT FOR SLABS



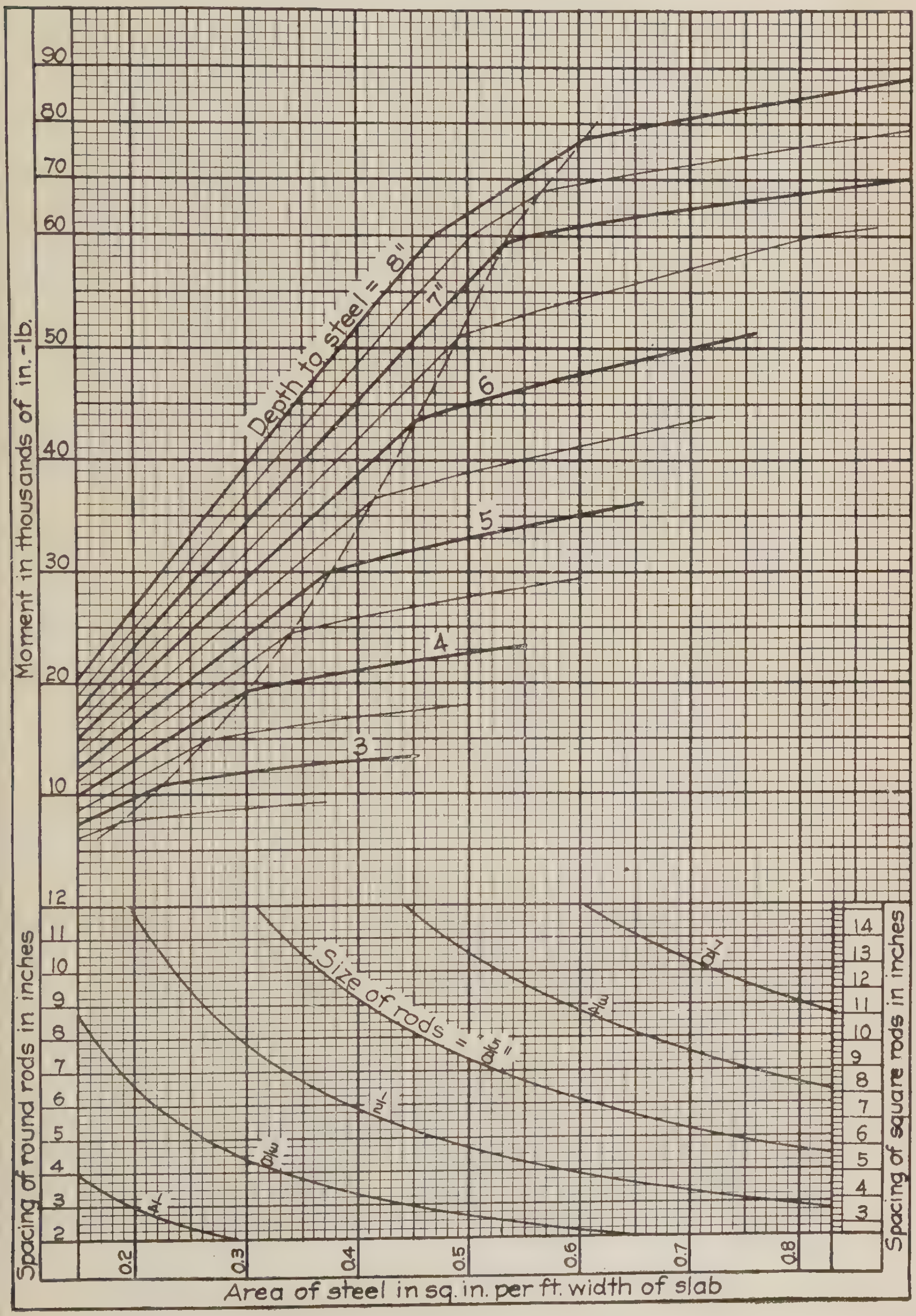
$f_c = 650$
$f_s = 16{,}000$
$n = 15$

## MOMENT OF RESISTANCE AND STEEL REQUIRED FOR SOLID CONCRETE SLABS



# MOMENT OF RESISTANCE AND STEEL REQUIRED FOR SOLID CONCRETE SLABS

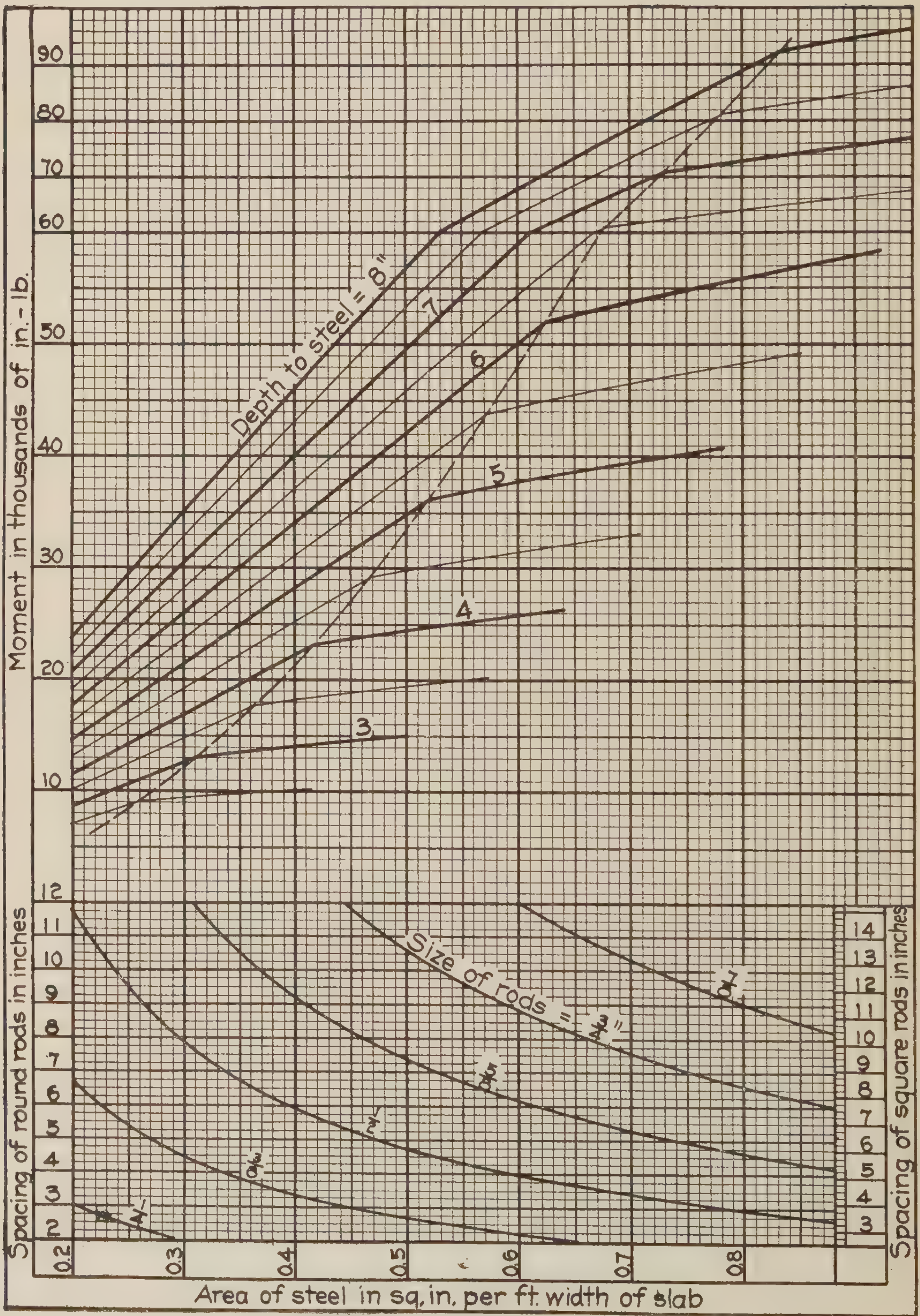
$f_c = 650$
$f_s = 18{,}000$
$n = 15$



SOLID
SLABS

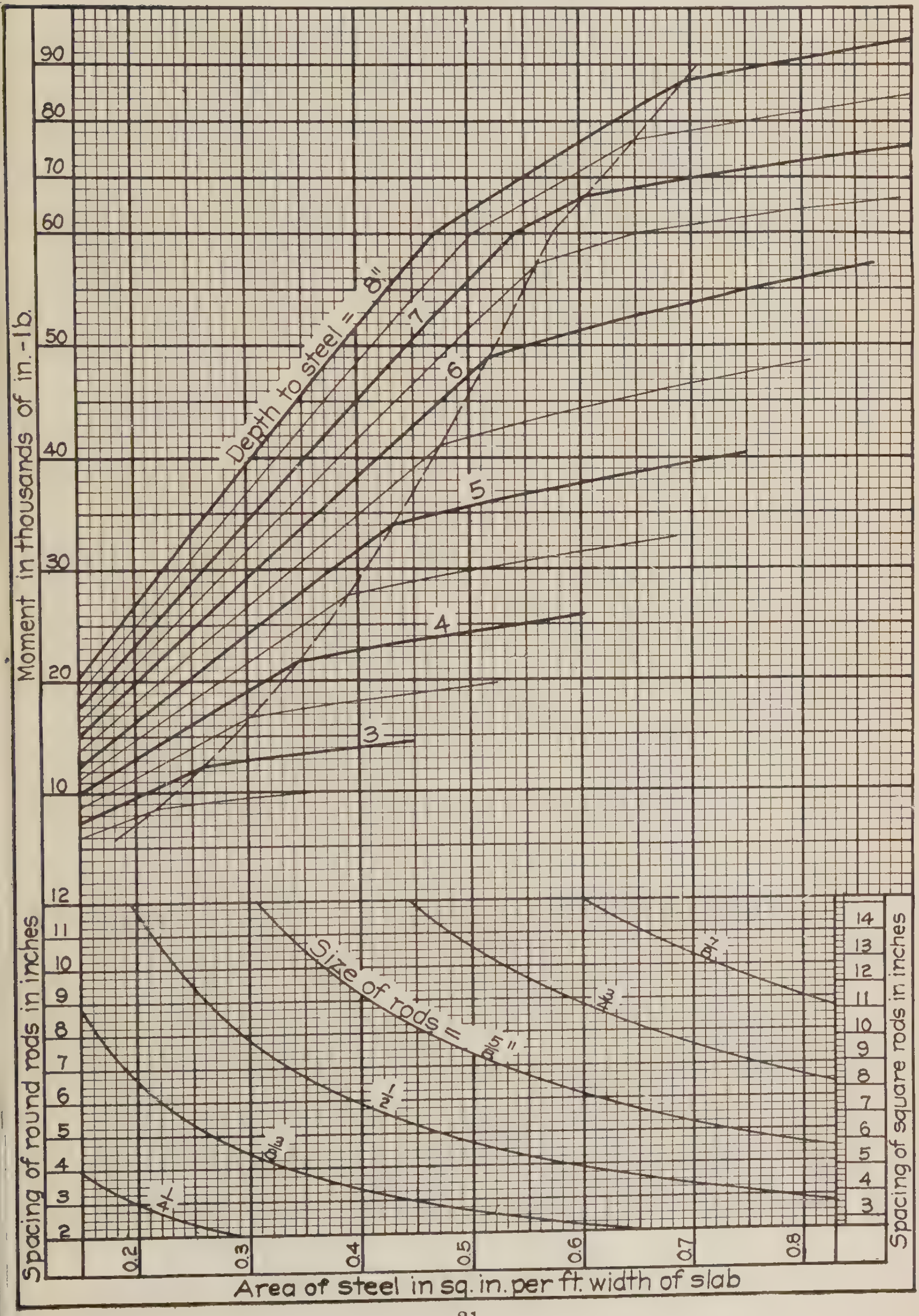
$f_c = 700$
$f_s = 16{,}000$
$n = 15$

# MOMENT OF RESISTANCE AND STEEL REQUIRED FOR SOLID CONCRETE SLABS



## MOMENT OF RESISTANCE AND STEEL REQUIRED FOR SOLID CONCRETE SLABS

$f_c = 700$
$f_s = 18{,}000$
$n = 15$



SOLID
SLABS

$f_c = 750$
$f_s = 16{,}000$
$n = 15$

## MOMENT OF RESISTANCE AND STEEL REQUIRED
## FOR
## SOLID CONCRETE SLABS

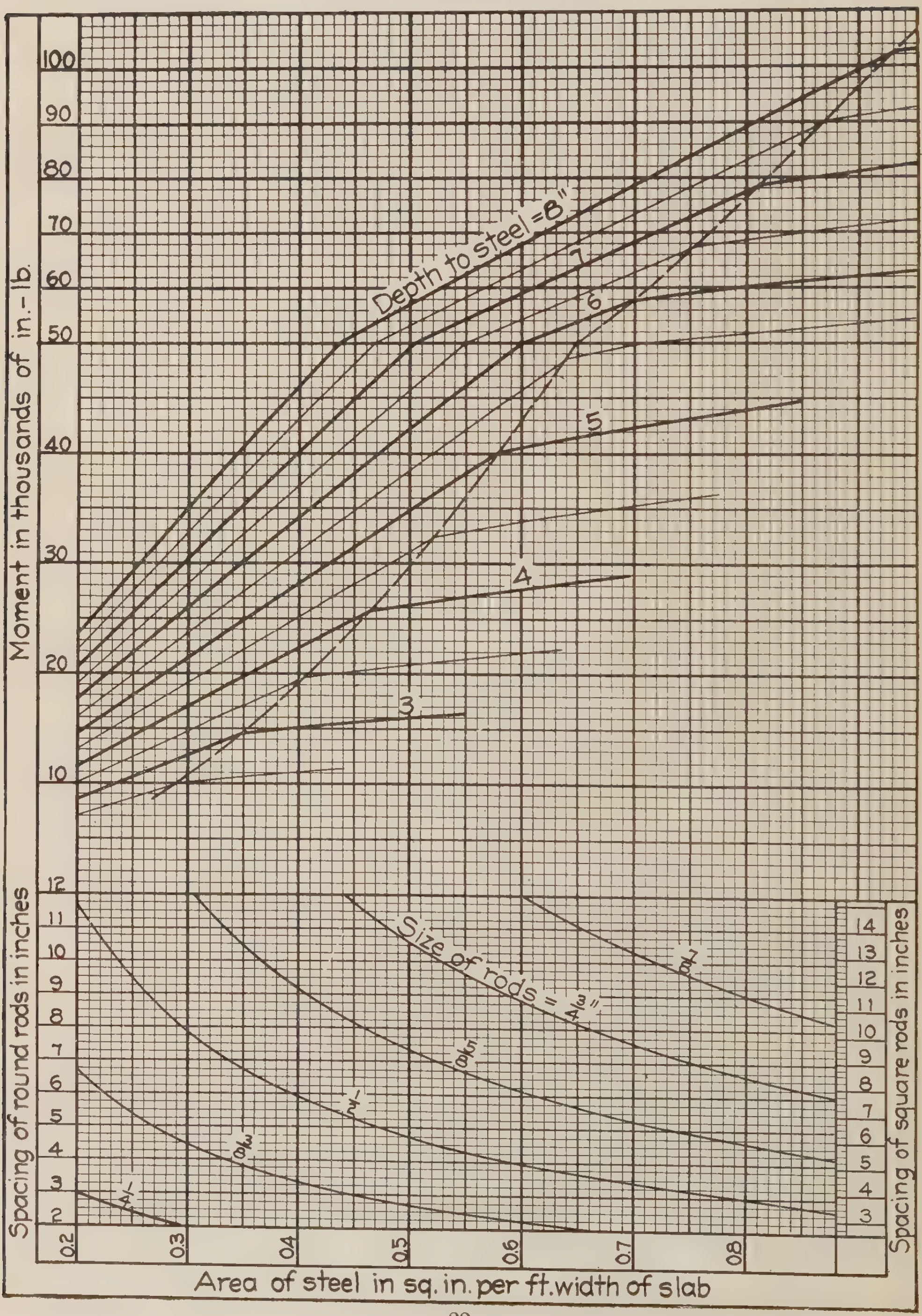
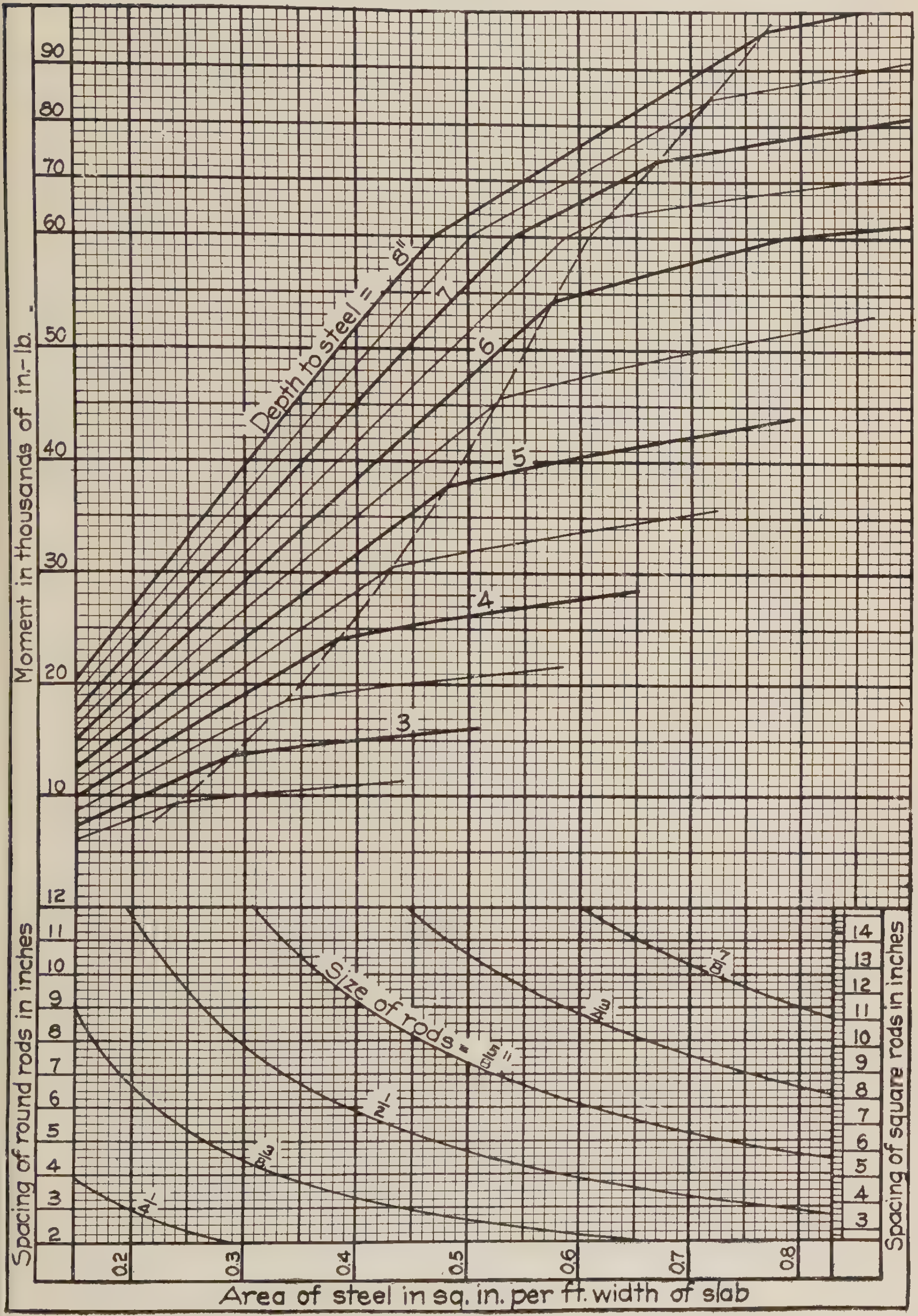


DIAGRAM 17

# MOMENT OF RESISTANCE AND STEEL REQUIRED FOR SOLID CONCRETE SLABS

$f_c = 750$
$f_s = 18{,}000$
$n = 15$



# SPACING OF RODS IN SLABS

## ROUND RODS

| Diameter (inches) | Sectional area of steel per foot of slab when spaced as follows: | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 in. | 2½ in. | 3 in. | 3½ in. | 4 in. | 4½ in. | 5 in. | 5½ in. | 6 in. | 7 in. | 8 in. | 9 in. | 10 in. | 12 in. |
| ¼ | 0.29 | 0.23 | 0.20 | 0.17 | 0.15 | 0.13 | 0.12 | | | | | | | |
| 5/16 | 0.46 | 0.36 | 0.31 | 0.26 | 0.23 | 0.20 | 0.18 | 0.17 | 0.15 | 0.13 | | | | |
| ⅜ | 0.66 | 0.53 | 0.44 | 0.38 | 0.33 | 0.29 | 0.26 | 0.24 | 0.22 | 0.19 | 0.17 | 0.15 | 0.13 | |
| 7/16 | 0.90 | 0.72 | 0.60 | 0.51 | 0.45 | 0.40 | 0.36 | 0.33 | 0.30 | 0.26 | 0.23 | 0.20 | 0.18 | 0.15 |
| ½ | 1.18 | 0.94 | 0.78 | 0.67 | 0.59 | 0.52 | 0.47 | 0.43 | 0.39 | 0.34 | 0.29 | 0.26 | 0.24 | 0.20 |
| 9/16 | 1.49 | 1.19 | 0.99 | 0.85 | 0.75 | 0.66 | 0.60 | 0.54 | 0.50 | 0.43 | 0.37 | 0.33 | 0.30 | 0.25 |
| ⅝ | 1.84 | 1.47 | 1.23 | 1.05 | 0.92 | 0.82 | 0.74 | 0.67 | 0.61 | 0.53 | 0.46 | 0.41 | 0.37 | 0.31 |
| 11/16 | 2.23 | 1.78 | 1.48 | 1.27 | 1.11 | 0.99 | 0.89 | 0.81 | 0.74 | 0.64 | 0.56 | 0.49 | 0.45 | 0.37 |
| ¾ | 2.65 | 2.12 | 1.77 | 1.51 | 1.32 | 1.18 | 1.06 | 0.96 | 0.88 | 0.76 | 0.66 | 0.59 | 0.53 | 0.44 |
| 13/16 | 3.11 | 2.48 | 2.07 | 1.78 | 1.56 | 1.38 | 1.24 | 1.13 | 1.04 | 0.89 | 0.78 | 0.69 | 0.62 | 0.52 |
| ⅞ | 3.61 | 2.88 | 2.40 | 2.06 | 1.80 | 1.60 | 1.44 | 1.31 | 1.20 | 1.03 | 0.90 | 0.80 | 0.72 | 0.60 |
| 15/16 | 4.14 | 3.31 | 2.76 | 2.37 | 2.07 | 1.84 | 1.66 | 1.51 | 1.38 | 1.18 | 1.03 | 0.92 | 0.83 | 0.69 |
| 1 | 4.71 | 3.77 | 3.14 | 2.69 | 2.36 | 2.09 | 1.88 | 1.71 | 1.57 | 1.35 | 1.18 | 1.05 | 0.94 | 0.78 |
| 1 ⅛ | .... | 4.77 | 3.98 | 3.41 | 2.98 | 2.65 | 2.39 | 2.17 | 1.99 | 1.70 | 1.49 | 1.33 | 1.19 | 0.99 |
| 1 ¼ | .... | .... | 4.91 | 4.21 | 3.68 | 3.27 | 2.95 | 2.68 | 2.45 | 2.10 | 1.84 | 1.64 | 1.47 | 1.23 |
| 1 ⅜ | .... | .... | .... | 5.09 | 4.45 | 3.96 | 3.56 | 3.24 | 2.97 | 2.55 | 2.23 | 1.98 | 1.78 | 1.48 |
| 1 ½ | .... | .... | .... | .... | 5.30 | 4.71 | 4.24 | 3.86 | 3.53 | 3.03 | 2.65 | 2.36 | 2.12 | 1.77 |

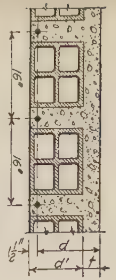
## SQUARE RODS

| Dimension (inches) | Sectional area of steel per foot of slab when spaced as follows: | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 in. | 2½ in. | 3 in. | 3½ in. | 4 in. | 4½ in. | 5 in. | 5½ in. | 6 in. | 7 in. | 8 in. | 9 in. | 10 in. | 12 in. |
| ¼ | 0.37 | 0.30 | 0.25 | 0.21 | 0.19 | 0.17 | 0.15 | 0.13 | 0.12 | | | | | |
| 5/16 | 0.59 | 0.47 | 0.39 | 0.33 | 0.29 | 0.26 | 0.23 | 0.21 | 0.19 | 0.17 | 0.15 | 0.13 | | |
| ⅜ | 0.84 | 0.67 | 0.56 | 0.48 | 0.42 | 0.37 | 0.34 | 0.31 | 0.28 | 0.24 | 0.21 | 0.19 | 0.17 | 0.14 |
| 7/16 | 1.15 | 0.92 | 0.77 | 0.66 | 0.57 | 0.51 | 0.46 | 0.42 | 0.38 | 0.33 | 0.29 | 0.25 | 0.23 | 0.19 |
| ½ | 1.50 | 1.20 | 1.00 | 0.86 | 0.75 | 0.67 | 0.60 | 0.55 | 0.50 | 0.43 | 0.37 | 0.33 | 0.30 | 0.25 |
| 9/16 | 1.90 | 1.52 | 1.27 | 1.08 | 0.95 | 0.84 | 0.76 | 0.69 | 0.63 | 0.54 | 0.47 | 0.42 | 0.38 | 0.32 |
| ⅝ | 2.34 | 1.87 | 1.56 | 1.34 | 1.17 | 1.04 | 0.94 | 0.85 | 0.78 | 0.67 | 0.59 | 0.52 | 0.47 | 0.39 |
| 11/16 | 2.84 | 2.27 | 1.99 | 1.62 | 1.42 | 1.33 | 1.13 | 1.03 | 0.94 | 0.81 | 0.71 | 0.66 | 0.57 | 0.47 |
| ¾ | 3.37 | 2.70 | 2.25 | 1.93 | 1.69 | 1.50 | 1.35 | 1.23 | 1.12 | 0.96 | 0.84 | 0.75 | 0.67 | 0.56 |
| 13/16 | 3.96 | 3.17 | 2.64 | 2.26 | 1.98 | 1.76 | 1.58 | 1.44 | 1.32 | 1.13 | 0.99 | 0.88 | 0.79 | 0.66 |
| ⅞ | 4.59 | 3.67 | 3.06 | 2.62 | 2.30 | 2.04 | 1.84 | 1.67 | 1.53 | 1.31 | 1.15 | 1.02 | 0.92 | 0.77 |
| 15/16 | 5.27 | 4.22 | 3.52 | 3.01 | 2.64 | 2.34 | 2.11 | 1.92 | 1.76 | 1.51 | 1.32 | 1.17 | 1.05 | 0.88 |
| 1 | 6.00 | 4.80 | 4.00 | 3.43 | 3.00 | 2.67 | 2.40 | 2.18 | 2.00 | 1.71 | 1.50 | 1.33 | 1.20 | 1.00 |
| 1 ⅛ | .... | 6.08 | 5.06 | 4.34 | 3.80 | 3.37 | 3.04 | 2.76 | 2.53 | 2.17 | 1.89 | 1.69 | 1.52 | 1.27 |
| 1 ¼ | .... | .... | 6.25 | 5.36 | 4.69 | 4.17 | 3.75 | 3.41 | 3.12 | 2.68 | 2.34 | 2.08 | 1.87 | 1.56 |
| 1 ⅜ | .... | .... | .... | 6.48 | 5.67 | 5.04 | 4.54 | 4.12 | 3.78 | 3.24 | 2.84 | 2.52 | 2.27 | 1.89 |
| 1 ½ | .... | .... | .... | .... | 6.75 | 6.00 | 5.40 | 4.91 | 4.50 | 3.86 | 3.37 | 3.00 | 2.70 | 2.25 |

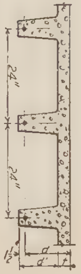
TABLE 2

**RIBBED SLABS**

# SAFE LOAD ON RIBBED SLABS



$f_c = 650$
$f_s = 16,000$
$n = 15$



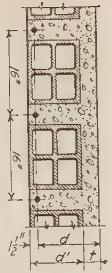
| Depth of joist $d'$ (in.) | Thickness of slab $t$ (in.) | Joists on 16-in. centers | | | Joists on 24-in. centers | | | Total safe load in pounds per square foot including weight of floor (dead and live) Based on $M = \frac{wl^2}{10}$. For $M = \frac{wl^2}{12}$, add 20% to load. For $M = \frac{wl^2}{8}$, deduct 20% from load. | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Resisting moment per joist (thousands of in.-lb.)* | Steel area per joist (sq. in.)* | Approx. weight per sq. ft. (lb.) | Resisting moment per joist (thousands of in.-lb.)† | Steel area per joist (sq. in.)† | Approx. weight per sq. ft. (lb.) | Span in feet | | | | | | | | | | | | | | | |
| | | | | | | | | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 24 | 26 | 28 | 30 |
| 4 | 2 | 35 | 0.56 | 50 | ... | .... | .. | 219 | 181 | 152 | 129 | 112 | 97 | 85 | 75 | | | | | | | | |
| | 2½ | 43 | 0.62 | 56 | ... | .... | .. | 269 | 222 | 187 | 159 | 137 | 119 | 105 | 93 | 83 | | | | | | | |
| | 3 | 52 | 0.68 | 63 | ... | .... | .. | 325 | 269 | 225 | 192 | 165 | 144 | 127 | 112 | 100 | 90 | | | | | | |
| 6 | 2 | 71 | 0.78 | 60 | 107 | 1.17 | 43 | 444 | 368 | 310 | 263 | 227 | 198 | 174 | 154 | 137 | 123 | 111 | 92 | 77 | | | |
| | 2½ | 84 | 0.86 | 67 | 126 | 1.29 | 50 | 525 | 433 | 364 | 310 | 268 | 233 | 205 | 181 | 162 | 145 | 131 | 108 | 91 | | | |
| | 3 | 97 | 0.93 | 73 | 145 | 1.39 | 56 | 606 | 500 | 420 | 358 | 308 | 269 | 236 | 209 | 186 | 167 | 151 | 125 | 105 | 89 | | |
| | 3½ | 110 | 0.99 | 79 | 165 | 1.48 | 62 | 687 | 568 | 477 | 407 | 351 | 305 | 268 | 238 | 212 | 190 | 172 | 142 | 119 | 102 | | |
| | 4 | 125 | 1.05 | 85 | 187 | 1.57 | 68 | 779 | 644 | 540 | 461 | 398 | 346 | 304 | 270 | 240 | 216 | 195 | 161 | 135 | 115 | 99 | |
| 8 | 2 | 110 | 0.90 | 73 | 166 | 1.36 | 50 | 687 | 568 | 477 | 407 | 351 | 305 | 268 | 238 | 212 | 190 | 172 | 142 | 119 | 102 | 88 | 76 |
| | 2½ | 132 | 1.03 | 79 | 198 | 1.54 | 56 | 825 | 682 | 573 | 488 | 421 | 367 | 322 | 285 | 255 | 228 | 206 | 170 | 143 | 122 | 105 | 92 |
| | 3 | 152 | 1.14 | 85 | 228 | 1.71 | 62 | ... | 786 | 660 | 562 | 435 | 422 | 371 | 329 | 293 | 263 | 237 | 196 | 165 | 140 | 121 | 105 |
| | 3½ | 171 | 1.22 | 92 | 256 | 1.83 | 69 | ... | 882 | 740 | 631 | 545 | 474 | 417 | 369 | 329 | 295 | 267 | 220 | 157 | 157 | 136 | 118 |
| | 4 | 189 | 1.29 | 98 | 284 | 1.93 | 75 | ... | ... | 822 | 700 | 604 | 526 | 462 | 410 | 365 | 328 | 296 | 244 | 205 | 175 | 151 | 131 |
| | 4½ | 208 | 1.35 | 104 | 312 | 2.03 | 81 | ... | ... | ... | 769 | 663 | 578 | 508 | 450 | 401 | 360 | 325 | 268 | 225 | 192 | 165 | 144 |
| | 5 | 227 | 1.42 | 110 | 340 | 2.13 | 87 | ... | ... | ... | 839 | 723 | 630 | 553 | 490 | 437 | 392 | 354 | 292 | 246 | 209 | 180 | 157 |
| 10 | 2 | 149 | 0.98 | 83 | 224 | 1.46 | 56 | .. | 772 | 648 | 552 | 476 | 415 | 365 | 323 | 288 | 258 | 233 | 193 | 162 | 138 | 119 | 103 |
| | 2½ | 181 | 1.14 | 89 | 272 | 1.71 | 62 | ... | 937 | 787 | 670 | 578 | 504 | 443 | 392 | 350 | 314 | 283 | 234 | 197 | 167 | 144 | 126 |
| | 3 | 211 | 1.29 | 95 | 316 | 1.93 | 68 | ... | ... | 915 | 779 | 672 | 585 | 515 | 456 | 406 | 365 | 329 | 272 | 228 | 194 | 168 | 146 |
| | 3½ | 238 | 1.40 | 102 | 357 | 2.10 | 75 | ... | ... | ... | 880 | 759 | 661 | 581 | 515 | 459 | 412 | 372 | 307 | 258 | 220 | 189 | 165 |
| | 4 | 265 | 1.51 | 108 | 397 | 2.26 | 81 | ... | ... | ... | ... | 845 | 735 | 646 | 572 | 510 | 458 | 413 | 342 | 287 | 244 | 211 | 183 |
| | 4½ | 290 | 1.60 | 114 | 435 | 2.39 | 87 | ... | ... | ... | ... | ... | 805 | 708 | 627 | 560 | 502 | 453 | 374 | 315 | 268 | 231 | 201 |
| | 5 | 313 | 1.66 | 120 | 470 | 2.49 | 93 | ... | ... | ... | ... | ... | ... | 765 | 677 | 605 | 542 | 490 | 405 | 340 | 289 | 250 | 217 |
| 12 | 2 | 190 | 1.03 | 93 | 285 | 1.54 | 62 | ... | ... | 825 | 703 | 606 | 528 | 464 | 411 | 367 | 329 | 297 | 245 | 206 | 175 | 151 | 132 |
| | 2½ | 232 | 1.22 | 99 | 348 | 1.83 | 68 | ... | ... | ... | 858 | 740 | 644 | 567 | 502 | 447 | 401 | 362 | 299 | 252 | 214 | 185 | 161 |
| | 3 | 269 | 1.38 | 106 | 403 | 2.07 | 74 | ... | ... | ... | ... | 857 | 746 | 656 | 581 | 518 | 465 | 420 | 346 | 291 | 248 | 214 | 186 |
| | 3½ | 307 | 1.53 | 112 | 460 | 2.30 | 80 | ... | ... | ... | ... | ... | 853 | 749 | 663 | 591 | 531 | 479 | 396 | 333 | 283 | 245 | 213 |
| | 4 | 340 | 1.65 | 118 | 510 | 2.48 | 87 | ... | ... | ... | ... | ... | ... | 830 | 735 | 656 | 589 | 531 | 439 | 369 | 314 | 272 | 236 |
| | 4½ | 374 | 1.77 | 124 | 561 | 2.65 | 93 | ... | ... | ... | ... | ... | ... | ... | 808 | 721 | 647 | 584 | 482 | 405 | 345 | 298 | 260 |
| | 5 | 407 | 1.87 | 131 | 610 | 2.81 | 99 | ... | ... | ... | ... | ... | ... | ... | ... | 785 | 704 | 635 | 525 | 441 | 376 | 325 | 282 |

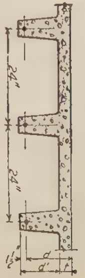
* For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 16.
† For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 24.

**RIBBED SLABS**

# SAFE LOAD ON RIBBED SLABS

$f_c = 700$
$f_s = 16{,}000$
$n = 15$





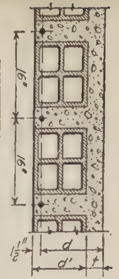
| Depth of joist $d'$ (in.) | Thickness of slab $t$ (in.) | Joists on 16-in. centers |  |  | Joists on 24-in. centers |  |  | Total safe load in pounds per square foot including weight of floor (dead and live). Based on $M = \frac{wl^2}{10}$. For $M = \frac{wl^2}{12}$, add 20% to load. For $M = \frac{wl^2}{8}$, deduct 20% from load. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Resisting moment per joist (thousands of in.-lb.)* | Steel area per joist (sq. in.)* | Approx. weight per sq. ft. (lb.) | Resisting moment per joist (thousands of in.-lb.)† | Steel area per joist (sq. in.)† | Approx. weight per sq. ft. (lb.) | Span in feet |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 24 | 26 | 28 | 30 |
| 4 | 2 | 30 | 0.63 | 50 | ... | .... | .. | 244 | 202 | 169 | 144 | 124 | 108 | 95 | 84 |  |  |  |  |  |  |  |  |
|  | 2½ | 48 | 0.70 | 56 | ... | .... | .. | 300 | 248 | 208 | 178 | 153 | 133 | 117 | 104 | 93 | 83 |  |  |  |  |  |  |
|  | 3 | 58 | 0.77 | 63 | ... | .... | .. | 362 | 300 | 252 | 215 | 185 | 161 | 142 | 125 | 112 | 100 | 91 |  |  |  |  |  |
| 6 | 2 | 79 | 0.86 | 60 | 118 | 1.29 | 43 | 494 | 408 | 343 | 292 | 252 | 219 | 193 | 171 | 152 | 137 | 123 | 102 | 86 | 73 |  |  |
|  | 2½ | 94 | 0.96 | 67 | 141 | 1.44 | 50 | 587 | 485 | 409 | 348 | 300 | 261 | 230 | 203 | 181 | 163 | 147 | 121 | 102 | 87 |  |  |
|  | 3 | 107 | 1.05 | 73 | 162 | 1.58 | 56 | 669 | 552 | 465 | 396 | 341 | 297 | 262 | 232 | 206 | 185 | 167 | 138 | 116 | 99 | 85 |  |
|  | 3½ | 123 | 1.11 | 79 | 185 | 1.67 | 62 | 768 | 635 | 534 | 455 | 392 | 342 | 300 | 266 | 237 | 213 | 192 | 159 | 133 | 114 | 98 |  |
|  | 4 | 139 | 1.19 | 85 | 209 | 1.79 | 68 | 869 | 718 | 604 | 514 | 443 | 386 | 340 | 301 | 268 | 241 | 217 | 179 | 151 | 129 | 111 | 96 |
| 8 | 2 | 120 | 0.99 | 73 | 180 | 1.48 | 50 | 750 | 620 | 521 | 444 | 382 | 333 | 293 | 260 | 232 | 208 | 188 | 155 | 130 | 111 | 96 | 83 |
|  | 2½ | 145 | 1.13 | 79 | 217 | 1.70 | 56 | 906 | 748 | 630 | 536 | 462 | 403 | 354 | 314 | 280 | 251 | 227 | 187 | 157 | 134 | 115 | 101 |
|  | 3 | 169 | 1.27 | 85 | 253 | 1.91 | 62 | ... | 872 | 734 | 625 | 539 | 470 | 413 | 366 | 326 | 292 | 264 | 218 | 183 | 156 | 135 | 117 |
|  | 3½ | 190 | 1.37 | 92 | 285 | 2.06 | 69 | ... | ... | 825 | 703 | 606 | 528 | 464 | 411 | 366 | 329 | 297 | 246 | 206 | 176 | 151 | 132 |
|  | 4 | 212 | 1.46 | 98 | 318 | 2.19 | 75 | ... | ... | ... | 784 | 676 | 589 | 519 | 459 | 409 | 368 | 332 | 274 | 230 | 196 | 169 | 147 |
|  | 4½ | 233 | 1.53 | 104 | 350 | 2.30 | 81 | ... | ... | ... | 863 | 743 | 648 | 570 | 505 | 450 | 404 | 364 | 301 | 253 | 215 | 186 | 162 |
|  | 5 | 256 | 1.61 | 110 | 384 | 2.42 | 87 | ... | ... | ... | ... | 816 | 711 | 626 | 554 | 494 | 444 | 400 | 330 | 278 | 237 | 204 | 178 |
| 10 | 2 | 164 | 1.07 | 83 | 246 | 1.61 | 56 | ... | 846 | 713 | 607 | 523 | 456 | 401 | 355 | 316 | 284 | 256 | 212 | 178 | 152 | 131 | 114 |
|  | 2½ | 198 | 1.24 | 89 | 297 | 1.86 | 62 | ... | ... | 860 | 733 | 632 | 550 | 484 | 429 | 382 | 343 | 310 | 256 | 215 | 183 | 158 | 138 |
|  | 3 | 230 | 1.40 | 95 | 345 | 2.10 | 68 | ... | ... | ... | 851 | 734 | 639 | 562 | 498 | 444 | 399 | 360 | 297 | 250 | 213 | 183 | 160 |
|  | 3½ | 263 | 1.55 | 102 | 394 | 2.33 | 75 | ... | ... | ... | ... | 839 | 731 | 643 | 570 | 507 | 455 | 411 | 340 | 285 | 243 | 210 | 183 |
|  | 4 | 292 | 1.67 | 108 | 438 | 2.51 | 81 | ... | ... | ... | ... | ... | 811 | 714 | 632 | 564 | 506 | 456 | 377 | 317 | 270 | 233 | 203 |
|  | 4½ | 322 | 1.77 | 114 | 483 | 2.66 | 87 | ... | ... | ... | ... | ... | ... | 787 | 696 | 621 | 558 | 503 | 416 | 349 | 298 | 257 | 224 |
|  | 5 | 350 | 1.86 | 120 | 525 | 2.79 | 93 | ... | ... | ... | ... | ... | ... | 856 | 758 | 675 | 607 | 547 | 452 | 380 | 324 | 279 | 233 |
| 12 | 2 | 208 | 1.12 | 93 | 312 | 1.68 | 62 | ... | ... | ... | 769 | 663 | 578 | 508 | 450 | 401 | 360 | 325 | 269 | 226 | 192 | 166 | 144 |
|  | 2½ | 251 | 1.32 | 99 | 377 | 1.98 | 68 | ... | ... | ... | ... | 800 | 697 | 614 | 544 | 484 | 435 | 392 | 324 | 271 | 232 | 200 | 175 |
|  | 3 | 295 | 1.51 | 106 | 442 | 2.27 | 74 | ... | ... | ... | ... | ... | 819 | 721 | 639 | 570 | 511 | 451 | 381 | 320 | 273 | 235 | 205 |
|  | 3½ | 335 | 1.68 | 112 | 503 | 2.52 | 80 | ... | ... | ... | ... | ... | ... | 820 | 725 | 646 | 580 | 524 | 433 | 363 | 310 | 267 | 233 |
|  | 4 | 375 | 1.82 | 118 | 562 | 2.73 | 87 | ... | ... | ... | ... | ... | ... | ... | 812 | 724 | 650 | 586 | 485 | 406 | 347 | 299 | 260 |
|  | 4½ | 414 | 1.96 | 124 | 622 | 2.94 | 93 | ... | ... | ... | ... | ... | ... | ... | ... | 800 | 717 | 648 | 535 | 451 | 383 | 331 | 289 |
|  | 5 | 450 | 2.07 | 131 | 675 | 3.11 | 99 | ... | ... | ... | ... | ... | ... | ... | ... | 869 | 780 | 704 | 581 | 488 | 416 | 359 | 313 |

* For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 16.

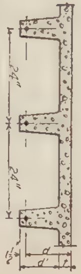
† For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 24.

TABLE 4

# SAFE LOAD ON RIBBED SLABS



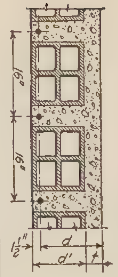
$f_c = 750$
$f_s = 16{,}000$
$n = 15$



| Depth of joist $d'$ (in.) | Thickness of slab $t$ (in.) | Joists on 16-in. centers | | | Joists on 24-in. centers | | | Total safe load in pounds per square foot including weight of floor (dead and live) Based on $M = \frac{wl^2}{10}$. For $M = \frac{wl^2}{12}$, add 20% to load. For $M = \frac{wl^2}{8}$, deduct 20% from load. | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Resisting moment per joist (thousands of in.-lb.)* | Steel area per joist (sq. in.)* | Approx. weight per sq. ft. (lb.) | Resisting moment per joist (thousands of in.-lb.)† | Steel area per joist (sq. in.)† | Approx. weight per sq. ft. (lb.) | Span in feet | | | | | | | | | | | | | | | |
| | | | | | | | | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 24 | 26 | 28 | 30 |
| 4 | 2 | 43 | 0.70 | 50 | ... | .... | .. | 269 | 222 | 187 | 159 | 137 | 119 | 105 | 93 | 83 | | | | | | | |
| | 2½ | 53 | 0.78 | 56 | ... | .... | .. | 331 | 274 | 230 | 196 | 169 | 147 | 129 | 115 | 102 | 92 | 83 | | | | | |
| | 3 | 64 | 0.85 | 63 | ... | .... | .. | 400 | 330 | 278 | 236 | 204 | 178 | 156 | 138 | 123 | 111 | 100 | | | | | |
| 6 | 2 | 86 | 0.94 | 60 | 129 | 1.41 | 43 | 537 | 444 | 374 | 318 | 273 | 239 | 210 | 186 | 166 | 149 | 134 | 111 | 93 | 79 | | |
| | 2½ | 103 | 1.06 | 67 | 154 | 1.59 | 50 | 644 | 532 | 448 | 381 | 328 | 286 | 252 | 223 | 199 | 178 | 161 | 133 | 112 | 95 | 82 | |
| | 3 | 120 | 1.16 | 73 | 180 | 1.74 | 56 | 750 | 619 | 521 | 444 | 382 | 334 | 293 | 259 | 232 | 208 | 187 | 155 | 130 | 111 | 96 | 83 |
| | 3½ | 137 | 1.24 | 79 | 205 | 1.86 | 62 | 856 | 707 | 595 | 507 | 437 | 381 | 335 | 297 | 264 | 237 | 214 | 177 | 149 | 127 | 109 | 95 |
| | 4 | 155 | 1.33 | 85 | 232 | 2.00 | 68 | ... | 800 | 674 | 573 | 494 | 431 | 379 | 335 | 299 | 268 | 242 | 200 | 168 | 143 | 123 | 108 |
| 8 | 2 | 131 | 1.08 | 73 | 196 | 1.62 | 50 | 819 | 676 | 569 | 485 | 418 | 364 | 320 | 284 | 252 | 227 | 205 | 169 | 142 | 121 | 104 | 91 |
| | 2½ | 158 | 1.24 | 79 | 237 | 1.86 | 56 | ... | 816 | 686 | 584 | 504 | 439 | 386 | 342 | 305 | 272 | 247 | 204 | 171 | 146 | 126 | 110 |
| | 3 | 184 | 1.38 | 85 | 276 | 2.07 | 62 | ... | ... | 799 | 681 | 587 | 511 | 450 | 398 | 355 | 318 | 287 | 238 | 200 | 170 | 147 | 128 |
| | 3½ | 209 | 1.51 | 92 | 315 | 2.27 | 69 | ... | ... | ... | 774 | 667 | 581 | 510 | 453 | 404 | 362 | 326 | 270 | 227 | 193 | 166 | 145 |
| | 4 | 235 | 1.62 | 98 | 352 | 2.43 | 75 | ... | ... | ... | 870 | 750 | 654 | 574 | 509 | 454 | 407 | 367 | 303 | 255 | 217 | 187 | 163 |
| | 4½ | 258 | 1.71 | 104 | 387 | 2.57 | 81 | ... | ... | ... | ... | 824 | 717 | 630 | 559 | 498 | 446 | 403 | 333 | 280 | 238 | 206 | 179 |
| | 5 | 283 | 1.79 | 110 | 424 | 2.69 | 87 | ... | ... | ... | ... | ... | 787 | 691 | 613 | 546 | 490 | 442 | 365 | 307 | 262 | 226 | 196 |
| 10 | 2 | 178 | 1.16 | 83 | 267 | 1.74 | 56 | .. | ... | 773 | 659 | 568 | 495 | 435 | 385 | 343 | 308 | 278 | 230 | 193 | 165 | 142 | 124 |
| | 2½ | 215 | 1.36 | 89 | 322 | 2.04 | 62 | ... | ... | ... | 796 | 686 | 598 | 525 | 465 | 415 | 372 | 336 | 278 | 233 | 199 | 171 | 149 |
| | 3 | 252 | 1.54 | 95 | 378 | 2.31 | 68 | ... | ... | ... | ... | 804 | 700 | 615 | 545 | 486 | 436 | 394 | 326 | 273 | 233 | 201 | 175 |
| | 3½ | 287 | 1.70 | 102 | 430 | 2.55 | 75 | ... | ... | ... | ... | ... | 798 | 701 | 621 | 554 | 497 | 448 | 370 | 311 | 265 | 228 | 199 |
| | 4 | 320 | 1.83 | 108 | 480 | 2.75 | 81 | ... | ... | ... | ... | ... | 890 | 782 | 693 | 617 | 554 | 500 | 413 | 346 | 296 | 255 | 222 |
| | 4½ | 354 | 1.96 | 114 | 531 | 2.94 | 87 | ... | ... | ... | ... | ... | ... | 865 | 766 | 684 | 613 | 553 | 457 | 384 | 327 | 282 | 246 |
| | 5 | 386 | 2.07 | 120 | 579 | 3.11 | 93 | ... | ... | ... | ... | ... | ... | ... | 835 | 745 | 669 | 603 | 499 | 419 | 357 | 308 | 268 |
| 12 | 2 | 225 | 1.22 | 93 | 337 | 1.83 | 62 | ... | ... | ... | 835 | 718 | 626 | 550 | 487 | 434 | 390 | 352 | 291 | 244 | 208 | 179 | 156 |
| | 2½ | 274 | 1.44 | 99 | 411 | 2.16 | 68 | ... | ... | ... | ... | 874 | 761 | 669 | 593 | 529 | 474 | 428 | 354 | 297 | 253 | 218 | 190 |
| | 3 | 321 | 1.65 | 106 | 481 | 2.47 | 74 | ... | ... | ... | ... | ... | 892 | 785 | 695 | 620 | 556 | 501 | 415 | 348 | 297 | 256 | 223 |
| | 3½ | 367 | 1.83 | 112 | 550 | 2.75 | 80 | ... | ... | ... | ... | ... | ... | 896 | 794 | 708 | 635 | 574 | 474 | 398 | 339 | 292 | 255 |
| | 4 | 409 | 1.98 | 118 | 613 | 2.97 | 87 | ... | ... | ... | ... | ... | ... | ... | 885 | 789 | 708 | 640 | 528 | 444 | 378 | 326 | 284 |
| | 4½ | 452 | 2.14 | 124 | 679 | 3.21 | 93 | ... | ... | ... | ... | ... | ... | ... | ... | 873 | 784 | 706 | 584 | 491 | 418 | 360 | 314 |
| | 5 | 493 | 2.27 | 131 | 740 | 3.40 | 99 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 854 | 770 | 637 | 535 | 456 | 393 | 342 |

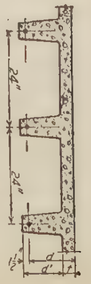
* For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 16.
† For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 24.

## RIBBED SLABS



# SAFE LOAD ON RIBBED SLABS

$f_c = 650$
$f_s = 18{,}000$
$n = 15$



| Depth of joist $d'$ (in.) | Thickness of slab $t$ (in.) | Joists on 16-in. centers | | | Joists on 24-in. centers | | | Total safe load in pounds per square foot including weight of floor (dead and live) Based on $M = \frac{wl^2}{10}$. For $M = \frac{wl^2}{12}$, add 20% to load. For $M = \frac{wl^2}{8}$, deduct 20% from load. Span in feet | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Resisting moment per joist (thousands of in.-lb.)* | Steel area per joist (sq. in.)* | Approx. weight per sq. ft. (lb.) | Resisting moment per joist (thousands of in.-lb.)† | Steel area per joist (sq. in.)† | Approx. weight per sq. ft. (lb.) | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 24 | 26 | 28 | 30 |
| 4 | 2 | 33 | 0.46 | 50 | ... | .... | .. | 206 | 170 | 143 | 122 | 105 | 92 | 80 | | | | | | | | | |
| | 2½ | 40 | 0.51 | 56 | ... | .... | .. | 250 | 206 | 174 | 148 | 127 | 111 | 98 | 86 | | | | | | | | |
| | 3 | 49 | 0.56 | 63 | ... | .... | .. | 306 | 253 | 213 | 181 | 156 | 136 | 120 | 106 | 95 | | | | | | | |
| 6 | 2 | 68 | 0.65 | 60 | 101 | 0.98 | 43 | 425 | 351 | 295 | 251 | 217 | 189 | 166 | 147 | 131 | 118 | 106 | 88 | 74 | | | |
| | 2½ | 79 | 0.71 | 67 | 118 | 1.07 | 50 | 494 | 408 | 343 | 292 | 252 | 220 | 193 | 171 | 152 | 137 | 123 | 102 | 86 | | | |
| | 3 | 91 | 0.76 | 73 | 136 | 1.15 | 56 | 569 | 470 | 396 | 337 | 290 | 253 | 222 | 197 | 176 | 157 | 142 | 117 | 99 | 84 | | |
| | 3½ | 103 | 0.81 | 79 | 155 | 1.22 | 62 | 644 | 532 | 448 | 381 | 328 | 286 | 252 | 223 | 199 | 178 | 161 | 133 | 112 | 95 | | |
| | 4 | 117 | 0.87 | 85 | 175 | 1.30 | 68 | 731 | 604 | 509 | 433 | 373 | 325 | 286 | 253 | 226 | 202 | 183 | 151 | 127 | 108 | 93 | |
| 8 | 2 | 106 | 0.77 | 73 | 159 | 1.16 | 50 | 663 | 548 | 461 | 392 | 338 | 294 | 259 | 230 | 204 | 183 | 166 | 137 | 115 | 98 | 84 | |
| | 2½ | 126 | 0.88 | 79 | 190 | 1.32 | 56 | 788 | 651 | 547 | 466 | 402 | 350 | 308 | 273 | 243 | 218 | 197 | 163 | 137 | 116 | 100 | 87 |
| | 3 | 145 | 0.96 | 85 | 217 | 1.44 | 62 | 906 | 749 | 630 | 536 | 462 | 403 | 354 | 314 | 280 | 251 | 226 | 187 | 157 | 134 | 115 | 100 |
| | 3½ | 161 | 1.01 | 92 | 242 | 1.52 | 69 | ... | 832 | 700 | 596 | 514 | 447 | 393 | 349 | 311 | 279 | 252 | 208 | 175 | 149 | 128 | 112 |
| | 4 | 178 | 1.07 | 98 | 267 | 1.60 | 75 | ... | ... | 774 | 659 | 568 | 495 | 434 | 386 | 343 | 308 | 278 | 230 | 193 | 165 | 142 | 124 |
| | 4½ | 195 | 1.12 | 104 | 293 | 1.67 | 81 | ... | ... | 848 | 722 | 622 | 541 | 476 | 422 | 376 | 338 | 305 | 252 | 212 | 180 | 155 | 135 |
| | 5 | 213 | 1.17 | 110 | 319 | 1.75 | 87 | ... | ... | ... | 789 | 680 | 592 | 520 | 461 | 411 | 369 | 333 | 275 | 231 | 197 | 170 | 148 |
| 10 | 2 | 146 | 0.84 | 83 | 218 | 1.26 | 56 | ... | 754 | 634 | 540 | 466 | 406 | 356 | 316 | 282 | 253 | 228 | 188 | 158 | 135 | 116 | 101 |
| | 2½ | 174 | 0.97 | 89 | 261 | 1.46 | 62 | ... | 899 | 756 | 644 | 555 | 483 | 425 | 377 | 336 | 301 | 272 | 224 | 189 | 161 | 139 | 121 |
| | 3 | 202 | 1.09 | 95 | 303 | 1.64 | 68 | ... | ... | 878 | 748 | 645 | 561 | 494 | 438 | 390 | 350 | 316 | 261 | 219 | 187 | 161 | 140 |
| | 3½ | 228 | 1.19 | 102 | 342 | 1.78 | 75 | ... | ... | ... | 844 | 728 | 634 | 556 | 393 | 440 | 395 | 356 | 294 | 247 | 211 | 182 | 158 |
| | 4 | 250 | 1.26 | 108 | 376 | 1.89 | 81 | ... | ... | ... | ... | 798 | 695 | 610 | 541 | 483 | 433 | 390 | 323 | 271 | 231 | 199 | 174 |
| | 4½ | 272 | 1.32 | 114 | 409 | 1.98 | 87 | ... | ... | ... | ... | 867 | 755 | 664 | 589 | 525 | 471 | 425 | 351 | 295 | 252 | 217 | 189 |
| | 5 | 293 | 1.37 | 120 | 440 | 2.05 | 93 | ... | ... | ... | ... | ... | 814 | 715 | 635 | 566 | 507 | 458 | 378 | 318 | 271 | 233 | 204 |
| 12 | 2 | 186 | 0.89 | 93 | 279 | 1.34 | 62 | ... | ... | 808 | 689 | 594 | 516 | 454 | 403 | 359 | 322 | 291 | 240 | 202 | 172 | 148 | 129 |
| | 2½ | 224 | 1.05 | 99 | 336 | 1.57 | 68 | ... | ... | ... | 829 | 715 | 622 | 546 | 485 | 432 | 388 | 350 | 289 | 243 | 206 | 179 | 155 |
| | 3 | 260 | 1.18 | 106 | 391 | 1.77 | 74 | ... | ... | ... | ... | 830 | 723 | 635 | 543 | 502 | 450 | 406 | 336 | 282 | 240 | 207 | 181 |
| | 3½ | 295 | 1.30 | 112 | 442 | 1.96 | 80 | ... | ... | ... | ... | ... | 820 | 720 | 639 | 570 | 511 | 461 | 381 | 320 | 273 | 235 | 205 |
| | 4 | 327 | 1.41 | 118 | 490 | 2.11 | 87 | ... | ... | ... | ... | ... | ... | 799 | 708 | 631 | 566 | 511 | 422 | 355 | 302 | 261 | 227 |
| | 4½ | 358 | 1.49 | 124 | 537 | 2.24 | 93 | ... | ... | ... | ... | ... | ... | 874 | 775 | 691 | 620 | 560 | 462 | 388 | 331 | 286 | 249 |
| | 5 | 386 | 1.56 | 131 | 579 | 2.33 | 99 | ... | ... | ... | ... | ... | ... | ... | 836 | 745 | 669 | 603 | 499 | 419 | 357 | 308 | 268 |

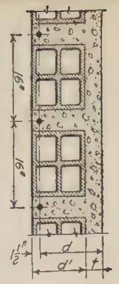
* For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 16.
† For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 24.

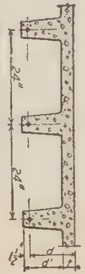
**TABLE 6**

**RIBBED SLABS**

## SAFE LOAD ON RIBBED SLABS

$f_c = 700$
$f_s = 18{,}000$
$n = 15$

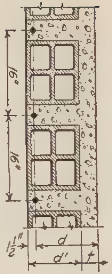




| Depth of joist $d'$ (in.) | Thickness of slab $t$ (in.) | Joists on 16-in. centers | | | Joists on 24-in. centers | | | Total safe load in pounds per square foot including weight of floor (dead and live) Based on $M = \frac{wl^2}{10}$. For $M = \frac{wl^2}{12}$, add 20 % to load. For $M = \frac{wl^2}{8}$, deduct 20 % from load. | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Resisting moment per joist (thousands of in.-lb.)* | Steel area per joist (sq. in.)* | Approx. weight per sq. ft. (lb.) | Resisting moment per joist (thousands of in.-lb.)† | Steel area per joist (sq. in.)† | Approx. weight per sq. ft. (lb.) | Span in feet | | | | | | | | | | | | | | | |
| | | | | | | | | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 24 | 26 | 28 | 30 |
| 4 | 2 | 37 | 0.52 | 50 | ... | ... | .. | 231 | 191 | 161 | 137 | 118 | 103 | 90 | 80 | | | | | | | | |
| | 2½ | 45 | 0.57 | 56 | ... | ... | .. | 281 | 232 | 195 | 166 | 143 | 125 | 110 | 97 | 87 | | | | | | | |
| | 3 | 55 | 0.63 | 63 | ... | .... | .. | 343 | 284 | 239 | 203 | 175 | 153 | 134 | 119 | 106 | 95 | | | | | | |
| 6 | 2 | 75 | 0.72 | 60 | 112 | 1.09 | 43 | 469 | 388 | 326 | 277 | 239 | 208 | 183 | 162 | 145 | 130 | 117 | 97 | 81 | 69 | | |
| | 2½ | 88 | 0.80 | 67 | 133 | 1.20 | 50 | 550 | 455 | 382 | 326 | 280 | 245 | 215 | 190 | 170 | 152 | 137 | 113 | 95 | 81 | | |
| | 3 | 102 | 0.86 | 73 | 153 | 1.29 | 56 | 637 | 527 | 443 | 377 | 325 | 284 | 249 | 220 | 197 | 176 | 159 | 132 | 111 | 94 | 81 | |
| | 3½ | 116 | 0.92 | 79 | 174 | 1.38 | 62 | 725 | 600 | 504 | 429 | 370 | 322 | 283 | 251 | 224 | 201 | 181 | 150 | 126 | 107 | 93 | |
| | 4 | 131 | 0.98 | 85 | 196 | 1.46 | 68 | 819 | 677 | 569 | 484 | 418 | 364 | 320 | 283 | 253 | 227 | 205 | 169 | 142 | 121 | 104 | |
| 8 | 2 | 117 | 0.85 | 73 | 175 | 1.27 | 50 | 731 | 605 | 509 | 433 | 373 | 325 | 286 | 253 | 226 | 202 | 183 | 151 | 127 | 108 | 93 | 81 |
| | 2½ | 139 | 0.97 | 79 | 209 | 1.45 | 56 | 868 | 718 | 604 | 514 | 443 | 386 | 340 | 301 | 268 | 240 | 217 | 180 | 151 | 129 | 111 | 96 |
| | 3 | 161 | 1.07 | 85 | 241 | 1.60 | 62 | ... | 832 | 700 | 595 | 514 | 447 | 393 | 348 | 311 | 279 | 251 | 208 | 175 | 149 | 128 | 112 |
| | 3½ | 181 | 1.15 | 92 | 271 | 1.72 | 69 | ... | ... | 786 | 670 | 577 | 503 | 442 | 392 | 349 | 313 | 283 | 234 | 196 | 167 | 144 | 126 |
| | 4 | 200 | 1.21 | 98 | 300 | 1.81 | 75 | ... | ... | 869 | 740 | 638 | 556 | 489 | 433 | 386 | 346 | 312 | 258 | 217 | 185 | 160 | 139 |
| | 4½ | 219 | 1.26 | 104 | 329 | 1.89 | 81 | ... | ... | ... | 811 | 699 | 609 | 535 | 474 | 423 | 379 | 342 | 283 | 238 | 202 | 175 | 152 |
| | 5 | 239 | 1.32 | 110 | 358 | 1.97 | 87 | ... | ... | ... | ... | 762 | 665 | 584 | 517 | 461 | 414 | 374 | 309 | 259 | 221 | 191 | 166 |
| 10 | 2 | 160 | 0.92 | 83 | 239 | 1.38 | 56 | ... | 827 | 695 | 592 | 510 | 445 | 391 | 346 | 309 | 277 | 250 | 207 | 174 | 148 | 127 | 111 |
| | 2½ | 192 | 1.07 | 89 | 287 | 1.61 | 62 | ... | ... | 834 | 710 | 612 | 534 | 469 | 415 | 370 | 332 | 300 | 248 | 208 | 177 | 153 | 133 |
| | 3 | 222 | 1.20 | 95 | 333 | 1.80 | 68 | ... | ... | ... | 821 | 708 | 617 | 542 | 480 | 428 | 384 | 347 | 287 | 241 | 205 | 177 | 154 |
| | 3½ | 252 | 1.32 | 102 | 379 | 1.98 | 75 | ... | ... | ... | ... | 804 | 700 | 615 | 545 | 486 | 436 | 394 | 326 | 273 | 233 | 201 | 175 |
| | 4 | 278 | 1.41 | 108 | 418 | 2.11 | 81 | ... | ... | ... | ... | 887 | 773 | 679 | 601 | 536 | 481 | 435 | 539 | 302 | 257 | 222 | 193 |
| | 4½ | 306 | 1.49 | 114 | 458 | 2.23 | 87 | ... | ... | ... | ... | ... | 851 | 747 | 662 | 591 | 530 | 478 | 396 | 332 | 283 | 244 | 213 |
| | 5 | 329 | 1.54 | 120 | 494 | 2.31 | 93 | ... | ... | ... | ... | ... | ... | 804 | 712 | 635 | 570 | 514 | 425 | 357 | 304 | 262 | 228 |
| 12 | 2 | 202 | 0.97 | 93 | 304 | 1.46 | 62 | ... | ... | 878 | 748 | 644 | 562 | 494 | 437 | 390 | 350 | 315 | 261 | 219 | 187 | 161 | 140 |
| | 2½ | 246 | 1.15 | 99 | 369 | 1.73 | 68 | ... | ... | ... | 910 | 785 | 684 | 601 | 532 | 475 | 426 | 384 | 318 | 267 | 227 | 196 | 171 |
| | 3 | 287 | 1.31 | 106 | 431 | 1.97 | 74 | ... | ... | ... | ... | 916 | 798 | 701 | 621 | 554 | 496 | 449 | 371 | 311 | 266 | 229 | 199 |
| | 3½ | 324 | 1.44 | 112 | 487 | 2.15 | 80 | ... | ... | ... | ... | ... | 901 | 791 | 701 | 625 | 561 | 506 | 419 | 351 | 299 | 258 | 225 |
| | 4 | 359 | 1.55 | 118 | 539 | 2.33 | 87 | ... | ... | ... | ... | ... | ... | 876 | 776 | 693 | 621 | 561 | 464 | 389 | 332 | 286 | 249 |
| | 4½ | 396 | 1.66 | 124 | 594 | 2.48 | 93 | ... | ... | ... | ... | ... | ... | ... | 856 | 764 | 685 | 618 | 511 | 429 | 366 | 316 | 275 |
| | 5 | 430 | 1.75 | 131 | 645 | 2.63 | 99 | ... | ... | ... | ... | ... | ... | ... | ... | 830 | 744 | 672 | 555 | 466 | 397 | 343 | 299 |

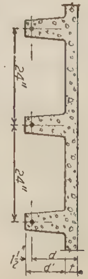
* For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 16.
† For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 24.

**RIBBED SLABS**



## SAFE LOAD ON RIBBED SLABS

$f_c = 750$
$f_s = 18{,}000$
$n = 15$



| Depth of joist $d'$ (in.) | Thickness of slab $t$ (in.) | Joists on 16-in. centers: Resisting moment per joist (thousands of in.-lb.)* | Joists on 16-in. centers: Steel area per joist (sq. in.)* | Joists on 16-in. centers: Approx. weight per sq. ft. (lb.) | Joists on 24-in. centers: Resisting moment per joist (thousands of in.-lb.)† | Joists on 24-in. centers: Steel area per joist (sq. in.)† | Joists on 24-in. centers: Approx. weight per sq. ft. (lb.) | Total safe load in pounds per square foot including weight of floor (dead and live). Based on $M = \frac{wl^2}{10}$. For $M = \frac{wl^2}{12}$, add 20% to load. For $M = \frac{wl^2}{8}$, deduct 20% from load. Span in feet: 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 24 | 26 | 28 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 2 | 41 | 0.58 | 50 | ... | .... | .. | 256 | 212 | 178 | 152 | 131 | 114 | 100 | 89 | 79 | | | | | | | |
| | 2½ | 50 | 0.64 | 56 | ... | .... | .. | 312 | 258 | 217 | 185 | 159 | 139 | 122 | 108 | 96 | 86 | | | | | | |
| | 3 | 61 | 0.71 | 63 | ... | .... | .. | 381 | 315 | 265 | 226 | 195 | 170 | 149 | 132 | 118 | 105 | 95 | | | | | |
| 6 | 2 | 82 | 0.80 | 60 | 124 | 1.20 | 43 | 512 | 423 | 356 | 303 | 262 | 228 | 200 | 177 | 158 | 142 | 128 | 106 | 89 | 76 | | |
| | 2½ | 98 | 0.90 | 67 | 148 | 1.35 | 50 | 612 | 506 | 426 | 362 | 312 | 272 | 239 | 212 | 189 | 169 | 153 | 127 | 106 | 90 | 78 | |
| | 3 | 113 | 0.96 | 73 | 170 | 1.44 | 56 | 706 | 584 | 491 | 418 | 360 | 314 | 276 | 244 | 218 | 196 | 176 | 146 | 123 | 104 | 90 | |
| | 3½ | 129 | 1.02 | 79 | 193 | 1.54 | 62 | 805 | 666 | 560 | 477 | 411 | 358 | 315 | 279 | 249 | 223 | 201 | 167 | 140 | 119 | 103 | 90 |
| | 4 | 145 | 1.09 | 85 | 217 | 1.63 | 68 | 906 | 749 | 630 | 536 | 462 | 403 | 354 | 314 | 280 | 251 | 226 | 187 | 157 | 134 | 115 | 101 |
| 8 | 2 | 127 | 0.93 | 73 | 191 | 1.39 | 50 | 794 | 656 | 552 | 470 | 405 | 353 | 310 | 274 | 245 | 220 | 198 | 164 | 138 | 117 | 101 | 88 |
| | 2½ | 153 | 1.06 | 79 | 229 | 1.59 | 56 | ... | 790 | 665 | 566 | 488 | 425 | 373 | 331 | 295 | 265 | 239 | 198 | 166 | 141 | 122 | 106 |
| | 3 | 177 | 1.18 | 85 | 266 | 1.77 | 62 | ... | 915 | 769 | 655 | 564 | 492 | 432 | 383 | 341 | 306 | 276 | 229 | 192 | 164 | 141 | 123 |
| | 3½ | 200 | 1.27 | 92 | 300 | 1.91 | 69 | ... | ... | 869 | 740 | 638 | 556 | 488 | 433 | 386 | 346 | 312 | 258 | 217 | 185 | 159 | 139 |
| | 4 | 222 | 1.35 | 98 | 333 | 2.02 | 75 | ... | ... | ... | 822 | 708 | 617 | 542 | 480 | 428 | 384 | 347 | 287 | 241 | 205 | 177 | 154 |
| | 4½ | 243 | 1.41 | 104 | 365 | 2.11 | 81 | ... | ... | ... | ... | 775 | 675 | 593 | 526 | 469 | 421 | 380 | 314 | 264 | 225 | 194 | 169 |
| | 5 | 266 | 1.47 | 110 | 399 | 2.21 | 87 | ... | ... | ... | ... | 848 | 739 | 650 | 575 | 513 | 460 | 415 | 344 | 289 | 246 | 212 | 185 |
| 10 | 2 | 173 | 1.00 | 83 | 259 | 1.50 | 56 | ... | ... | 751 | 640 | 542 | 481 | 422 | 374 | 334 | 300 | 270 | 223 | 188 | 160 | 138 | 120 |
| | 2½ | 209 | 1.17 | 89 | 314 | 1.75 | 62 | ... | ... | 907 | 773 | 666 | 581 | 510 | 454 | 403 | 362 | 326 | 270 | 227 | 193 | 167 | 145 |
| | 3 | 243 | 1.32 | 95 | 364 | 1.98 | 68 | ... | ... | ... | 900 | 775 | 675 | 593 | 526 | 469 | 421 | 379 | 314 | 264 | 225 | 194 | 169 |
| | 3½ | 276 | 1.45 | 102 | 415 | 2.18 | 75 | ... | ... | ... | ... | 880 | 767 | 674 | 597 | 532 | 478 | 431 | 357 | 299 | 255 | 220 | 192 |
| | 4 | 307 | 1.56 | 108 | 460 | 2.33 | 81 | ... | ... | ... | ... | ... | 854 | 750 | 664 | 592 | 532 | 479 | 397 | 333 | 284 | 245 | 213 |
| | 4½ | 338 | 1.65 | 114 | 507 | 2.48 | 87 | ... | ... | ... | ... | ... | ... | 826 | 731 | 652 | 585 | 528 | 437 | 367 | 312 | 270 | 235 |
| | 5 | 367 | 1.73 | 120 | 550 | 2.60 | 93 | ... | ... | ... | ... | ... | ... | ... | 794 | 708 | 636 | 573 | 474 | 398 | 339 | 293 | 255 |
| 12 | 2 | 220 | 1.06 | 93 | 330 | 1.59 | 62 | ... | ... | ... | 814 | 702 | 611 | 537 | 476 | 424 | 381 | 343 | 284 | 239 | 203 | 175 | 153 |
| | 2½ | 268 | 1.25 | 99 | 402 | 1.88 | 68 | ... | ... | ... | ... | 855 | 745 | 654 | 580 | 517 | 464 | 419 | 346 | 291 | 248 | 214 | 186 |
| | 3 | 311 | 1.42 | 106 | 467 | 2.13 | 74 | ... | ... | ... | ... | ... | 865 | 759 | 673 | 600 | 539 | 486 | 402 | 337 | 288 | 248 | 216 |
| | 3½ | 355 | 1.58 | 112 | 532 | 2.36 | 80 | ... | ... | ... | ... | ... | ... | 867 | 768 | 685 | 615 | 554 | 459 | 385 | 328 | 283 | 246 |
| | 4 | 395 | 1.71 | 118 | 592 | 2.56 | 87 | ... | ... | ... | ... | ... | ... | ... | 855 | 762 | 684 | 617 | 510 | 429 | 365 | 315 | 274 |
| | 4½ | 436 | 1.83 | 124 | 653 | 2.74 | 93 | ... | ... | ... | ... | ... | ... | ... | ... | 841 | 756 | 681 | 564 | 474 | 404 | 348 | 303 |
| | 5 | 475 | 1.94 | 131 | 712 | 2.91 | 99 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 823 | 741 | 614 | 515 | 439 | 379 | 330 |

* For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 16.

† For other spacing of joists multiply the values in these columns by the distance center to center of joists and divide by 24.

# SECTION 2

## FLAT SLABS

The designs of square interior flat slab panels according to the American Concrete Institute recommendations, and the New York and Chicago Codes are given in Tables 8 to 13 inclusive. These are for panels from 16 to 26 ft. square, both with and without drops, and for live loads from 100 to 350 lb. per sq. ft. of floor. An allowance of 6 lb. per sq. ft. was made for weight of finish.

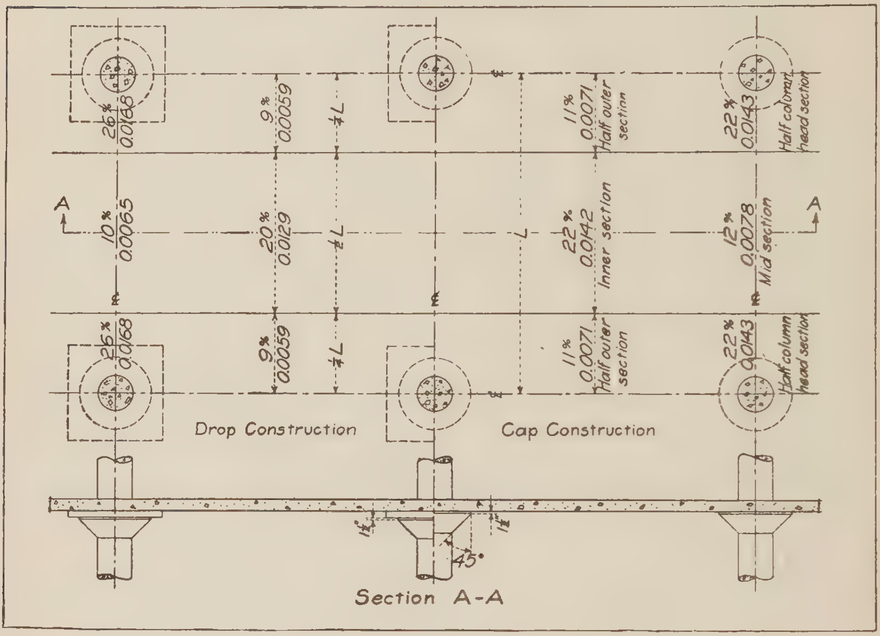
The quantities given are believed to be conservative and by careful detailing it will usually be found possible to keep the weight of the steel slightly below that given in the tables.

Rectangular panels and wall panels must be designed according to the special requirements of the different codes.

Columns supporting flat slab floors must be designed to take the bending moments produced by the cantilever action of the slab. After the bending moments in the columns have been estimated, the stresses may be determined by the diagrams of Section 8. The majority of columns used have round hooped cores and Diagrams 60 to 64 inclusive have been constructed for the design of such columns when subjected to bending.

## FLAT SLAB FLOORS
## AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS
## INTERIOR SQUARE PANELS

***$f_c = 650$ for positive moment***
***$f_c = 750$ for negative moment***
***$f_s = 16{,}000$***
***$n = 15$***



**Bending Moment Coefficients**

Moment coefficients shown on diagram are to be multiplied by $WL$.

$W = wL^2$.
$w$ = total dead and live load in pounds per square foot.
$L$ = span center to center of columns for square panels.

Values shown above moment coefficients are percentages of numerical sum of moments in one direction across panel.

Numerical sum of moments in one direction across panel $= 0.0648WL$.

Minimum size of drop $= 0.3L$.

Minimum diameter of capital $= 0.225L$.

$$\text{Minimum } t = \begin{cases} 0.02L\sqrt{w} + 1 \ (t \text{ in inches, } L \text{ in feet}) \\ L/32 \end{cases}$$

$t$ = total thickness of slab.

TABLE 8

# FLAT SLAB FLOORS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS INTERIOR SQUARE PANELS

## DROP CONSTRUCTION

***$f_c = 650$ for positive moment***
***$f_c = 750$ for negative moment***
***$f_s = 16{,}000$***
***$n = 15$***

Superimposed load = 100 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 4′ 10″×4′ 10″ | 6 | 2¼ | 0.52 | 14-⅜″ | 8-⅜″ | 11-⅜″ | 1.95 |
| 17×17 | 3′ 9″ | 5′ 2″×5′ 2″ | 6½ | 2¼ | 0.56 | 16-⅜″ | 9-⅜″ | 13-⅜″ | 2.14 |
| 18×18 | 4′ 0″ | 5′ 6″×5′ 6″ | 6¾ | 2½ | 0.58 | 18 ⅜″ | 10-⅜″ | 15 ⅜″ | 2.25 |
| 19×19 | 4′ 3″ | 5′ 8″×5′ 8″ | 7¼ | 2½ | 0.62 | 21-⅜″ | 11-⅜″ | 16-⅜″ | 2.38 |
| 20×20 | 4′ 6″ | 6′ 0″×6′ 0″ | 7½ | 2¾ | 0.65 | 17-7⁄16″ | 9-7⁄16″ | 15 7⁄16″ | 2.53 |
| 21×21 | 4′ 9″ | 6′ 4″×6′ 4″ | 8 | 2¾ | 0.69 | 20-7⁄16″ | 10-7⁄16″ | 16-7⁄16″ | 2.70 |
| 22×22 | 5′ 0″ | 6′ 8″×6′ 8″ | 8¼ | 3¼ | 0.71 | 21-7⁄16″ | 12-7⁄16″ | 16-7⁄16″ | 2.81 |
| 23×23 | 5′ 3″ | 7′ 0″×7′ 0″ | 8¾ | 3½ | 0.76 | 23-7⁄16″ | 13-7⁄16″ | 18-7⁄16″ | 3.06 |
| 24×24 | 5′ 6″ | 7′ 4″×7′ 4″ | 9 | 3½ | 0.78 | 26-7⁄16″ | 14-7⁄16″ | 21-7⁄16″ | 3.30 |
| 25×25 | 5′ 9″ | 7′ 6″×7′ 6″ | 9½ | 3½ | 0.82 | 29-7⁄16″ | 16-7⁄16″ | 23-7⁄16″ | 3.44 |
| 26×26 | 6′ 0″ | 7′ 10″×7′ 10″ | 9¾ | 3¾ | 0.84 | 31-7⁄16″ | 17-7⁄16″ | 25-7⁄16″ | 3.55 |

Superimposed load = 150 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 4′ 10″×4′ 10″ | 6 | 2¾ | 0.52 | 18-⅜″ | 10-⅜″ | 15 ⅜″ | 2.54 |
| 17×17 | 3′ 9″ | 5′ 2″×5′ 2″ | 6½ | 2¾ | 0.56 | 20-⅜″ | 11-⅜″ | 16-⅜″ | 2.56 |
| 18×18 | 4′ 0″ | 5′ 6″×5′ 6″ | 6¾ | 3¼ | 0.59 | 23 ⅜″ | 14-⅜″ | 19 ⅜″ | 2.90 |
| 19×19 | 4′ 3″ | 5′ 8″×5′ 8″ | 7¼ | 3¼ | 0.63 | 26-⅜″ | 14-⅜″ | 20-⅜″ | 3.00 |
| 20×20 | 4′ 6″ | 6′ 0″×6′ 0″ | 7½ | 3½ | 0.65 | 22-7⁄16″ | 12-7⁄16″ | 17-7⁄16″ | 3.27 |
| 21×21 | 4′ 9″ | 6′ 4″×6′ 4″ | 8 | 3½ | 0.69 | 24-7⁄16″ | 13-7⁄16″ | 20 7⁄16″ | 3.52 |
| 22×22 | 5′ 0″ | 6′ 8″×6′ 8″ | 8¼ | 4 | 0.72 | 26-7⁄16″ | 14-7⁄16″ | 22 7⁄16″ | 3.62 |
| 23×23 | 5′ 3″ | 7′ 0″×7′ 0″ | 8¾ | 4 | 0.76 | 29 7⁄16″ | 16-7⁄16″ | 23-7⁄16″ | 3.78 |
| 24×24 | 5′ 6″ | 7′ 4″×7′ 4″ | 9 | 4¼ | 0.78 | 31 7⁄16″ | 18-7⁄16″ | 26-7⁄16″ | 3.98 |
| 25×25 | 5′ 9″ | 7′ 6″×7′ 6″ | 9½ | 4½ | 0.83 | 35-7⁄16″ | 20-7⁄16″ | 29-7⁄16″ | 4.27 |
| 26×26 | 6′ 0″ | 7′ 10″×7′ 10″ | 9¾ | 4¾ | 0.85 | 39-7⁄16″ | 21-7⁄16″ | 31-7⁄16″ | 4.45 |

Superimposed load = 200 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 4′ 10″×4′ 10″ | 6½ | 3 | 0.58 | 20-⅜″ | 11-⅜″ | 17-⅜″ | 2.83 |
| 17×17 | 3′ 9″ | 5′ 2″×5′ 2″ | 6¾ | 3¼ | 0.59 | 24-⅜″ | 13-⅜″ | 19-⅜″ | 3.07 |
| 18×18 | 4′ 0″ | 5′ 6″×5′ 6″ | 7¼ | 3¾ | 0.63 | 26-⅜″ | 15-⅜″ | 22-⅜″ | 3.45 |
| 19×19 | 4′ 3″ | 5′ 8″×5′ 8″ | 7½ | 4 | 0.66 | 30-⅜″ | 16-⅜″ | 25-⅜″ | 3.50 |
| 20×20 | 4′ 6″ | 6′ 0″×6′ 0″ | 8 | 4 | 0.70 | 25-7⁄16″ | 13-7⁄16″ | 20 7⁄16″ | 3.70 |
| 21×21 | 4′ 9″ | 6′ 4″×6′ 4″ | 8¼ | 4¼ | 0.72 | 27-7⁄16″ | 16 7⁄16″ | 22-7⁄16″ | 3.87 |
| 22×22 | 5′ 0″ | 6′ 8″×6′ 8″ | 8¾ | 4½ | 0.76 | 30 7⁄16″ | 17 7⁄16″ | 25-7⁄16″ | 4.15 |
| 23×23 | 5′ 3″ | 7′ 0″×7′ 0″ | 9¼ | 4½ | 0.81 | 33-7⁄16″ | 18 7⁄16″ | 26-7⁄16″ | 4.26 |
| 24×24 | 5′ 6″ | 7′ 4″×7′ 4″ | 9½ | 5 | 0.83 | 36-7⁄16″ | 20-7⁄16″ | 30-7⁄16″ | 4.45 |
| 25×25 | 5′ 9″ | 7′ 6″×7′ 6″ | 10 | 5 | 0.87 | 39-7⁄16″ | 22-7⁄16″ | 31-7⁄16″ | 4.59 |
| 26×26 | 6′ 0″ | 7′ 10″×7′ 10″ | 10½ | 5¼ | 0.92 | 43-7⁄16″ | 23-7⁄16″ | 35-7⁄16″ | 4.92 |

TABLE 8

## FLAT SLAB FLOORS
## AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS
## INTERIOR SQUARE PANELS

### DROP CONSTRUCTION

$f_c = 650$ *for positive moment*
$f_c = 750$ *for negative moment*
$f_s = 16{,}000$
$n = 15$

Superimposed load = 250 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 4′ 10″×4′ 10″ | 7 | 3¼ | 0.61 | 22 3/8″ | 12-3/8″ | 18-3/8″ | 3.05 |
| 17×17 | 3′ 9″ | 5′ 2″×5′ 2″ | 7½ | 3½ | 0.65 | 25-3/8″ | 14 3/8″ | 20 3/8″ | 3.32 |
| 18×18 | 4′ 0″ | 5′ 6″×5′ 6″ | 7¾ | 4 | 0.68 | 28 3/8″ | 17-3/8″ | 23 3/8″ | 3.55 |
| 19×19 | 4′ 3″ | 5′ 8″×5′ 8″ | 8¼ | 4¼ | 0.72 | 23-7/16″ | 13-7/16″ | 20 7/16″ | 3.77 |
| 20×20 | 4′ 6″ | 6′ 0″×6′ 0″ | 8½ | 4½ | 0.74 | 27-7/16″ | 14 7/16″ | 22-7/16″ | 4.00 |
| 21×21 | 4′ 9″ | 6′ 4″×6′ 4″ | 9 | 4½ | 0.79 | 30-7/16″ | 16-7/16″ | 23-7/16″ | 4.15 |
| 22×22 | 5′ 0″ | 6′ 8″×6′ 8″ | 9½ | 4¾ | 0.83 | 33-7/16″ | 18-7/16″ | 26-7/16″ | 4.42 |
| 23×23 | 5′ 3″ | 7′ 0″×7′ 0″ | 10 | 5 | 0.87 | 35 7/16″ | 20-7/16″ | 29 7/16″ | 4.60 |
| 24×24 | 5′ 6″ | 7′ 4″×7′ 4″ | 10½ | 5 | 0.91 | 39-7/16″ | 22-7/16″ | 31-7/16″ | 4.81 |
| 25×25 | 5′ 9″ | 7′ 6″×7′ 6″ | 11 | 5¼ | 0.96 | 43-7/16″ | 23 7/16″ | 36 7/16″ | 5.21 |
| 26×26 | 6′ 0″ | 7′ 10″×7′ 10″ | 11½ | 5¾ | 0.98 | 47-7/16″ | 26-7/16″ | 38-7/16″ | 5.39 |

Superimposed load = 300 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 4′ 10″×4′ 10″ | 7½ | 3¾ | 0.66 | 25-3/8″ | 14-3/8″ | 19-3/8″ | 3.35 |
| 17×17 | 3′ 9″ | 5′ 2″×5′ 2″ | 7¾ | 4¼ | 0.68 | 29 3/8″ | 16-3/8″ | 23-3/8″ | 3.70 |
| 18×18 | 4′ 0″ | 5′ 6″×5′ 6″ | 8¼ | 4¼ | 0.72 | 31-3/8″ | 18 3/8″ | 25-3/8″ | 3.83 |
| 19×19 | 4′ 3″ | 5′ 8″×5′ 8″ | 8¾ | 4¾ | 0.77 | 26-7/16″ | 14-7/16″ | 21-7/16″ | 4.07 |
| 20×20 | 4′ 6″ | 6′ 0″×6′ 0″ | 9¼ | 4¾ | 0.81 | 29 7/16″ | 16 7/16″ | 23-7/16″ | 4.30 |
| 21×21 | 4′ 9″ | 6′ 4″×6′ 4″ | 9¾ | 5 | 0.85 | 31 7/16″ | 17-7/16″ | 26-7/16″ | 4.47 |
| 22×22 | 5′ 0″ | 6′ 8″×6′ 8″ | 10 | 5½ | 0.88 | 35-7/16″ | 20-7/16″ | 29-7/16″ | 4.82 |
| 23×23 | 5′ 3″ | 7′ 0″×7′ 0″ | 10½ | 5¾ | 0.92 | 36 7/16″ | 21-7/16″ | 30 7/16″ | 4.77 |
| 24×24 | 5′ 6″ | 7′ 4″×7′ 4″ | 11 | 6¼ | 0.96 | 33 ½″ | 18-½″ | 26-½″ | 5.25 |
| 25×25 | 5′ 9″ | 7′ 6″×7′ 6″ | 11½ | 6½ | 1.01 | 35 ½″ | 20 ½″ | 29 ½″ | 5.52 |
| 26×26 | 6′ 0″ | 7′ 10″×7′ 10″ | 12 | 7 | 1.05 | 39-½″ | 22-½″ | 31 ½″ | 5.77 |

Superimposed load = 350 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 4′ 10″×4′ 10″ | 7¾ | 4¾ | 0.68 | 27-3/8″ | 14-3/8″ | 23 3/8″ | 3.79 |
| 17×17 | 3′ 9″ | 5′ 2″×5′ 2″ | 8¼ | 5 | 0.73 | 30 3/8″ | 16 3/8″ | 25-3/8″ | 3.91 |
| 18×18 | 4′ 0″ | 5′ 6″×5′ 6″ | 8¾ | 5¼ | 0.77 | 26 7/16″ | 13-7/16″ | 20-7/16″ | 4.10 |
| 19×19 | 4′ 3″ | 5′ 8″×5′ 8″ | 9¼ | 5¾ | 0.82 | 27-7/16″ | 14-7/16″ | 22-7/16″ | 4.27 |
| 20×20 | 4′ 6″ | 6′ 0″×6′ 0″ | 9¾ | 6 | 0.86 | 30-7/16″ | 17-7/16″ | 25-7/16″ | 4.55 |
| 21×21 | 4′ 9″ | 6′ 4″×6′ 4″ | 10¼ | 6¼ | 0.90 | 34-7/16″ | 18-7/16″ | 27 7/16″ | 4.81 |
| 22×22 | 5′ 0″ | 6′ 8″×6′ 8″ | 10¾ | 6¾ | 0.95 | 36-7/16″ | 21 7/16″ | 30-7/16″ | 4.96 |
| 23×23 | 5′ 3″ | 7′ 0″×7′ 0″ | 11¼ | 7¼ | 0.99 | 40-7/16″ | 23 7/16″ | 33-7/16″ | 5.26 |
| 24×24 | 5′ 6″ | 7′ 4″×7′ 4″ | 11¾ | 7¾ | 1.04 | 34-½″ | 19 ½″ | 28-½″ | 5.54 |
| 25×25 | 5′ 9″ | 7′ 6″×7′ 6″ | 12¼ | 8¼ | 1.09 | 37-½″ | 21-½″ | 30-½″ | 5.76 |
| 26×26 | 6′ 0″ | 7′ 10″×7′ 10″ | 12¾ | 8½ | 1.13 | 41-½″ | 22-½″ | 33-½″ | 6.07 |

TABLE 9

# FLAT SLAB FLOORS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS INTERIOR SQUARE PANELS

## CAP CONSTRUCTION

$f_c = 650$ *for positive moment*
$f_c = 750$ *for negative moment*
$f_s = 16{,}000$
$n = 15$

Superimposed load = 100 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 6½ | 0.542 | 17-⅜″ | 4-⅜″ | 9-⅜″ | 13-⅜″ | 2.54 |
| 17×17 | 3′ 9″ | 6¾ | 0.563 | 20-⅜″ | 4-⅜″ | 11-⅜″ | 15-⅜″ | 2.66 |
| 18×18 | 4′ 0″ | 7 | 0.584 | 23-⅜″ | 5-⅜″ | 12-⅜″ | 17-⅜″ | 2.84 |
| 19×19 | 4′ 3″ | 7½ | 0.625 | 25-⅜″ | 5-⅜″ | 13-⅜″ | 19-⅜″ | 3.04 |
| 20×20 | 4′ 6″ | 8 | 0.667 | 21-7/16″ | 4-7/16″ | 11-7/16″ | 16-7/16″ | 3.24 |
| 21×21 | 4′ 9″ | 8¼ | 0.688 | 24-7/16″ | 4-7/16″ | 13-7/16″ | 18-7/16″ | 3.45 |
| 22×22 | 5′ 0″ | 8¾ | 0.730 | 26-7/16″ | 5-7/16″ | 14-7/16″ | 19-7/16″ | 3.62 |
| 23×23 | 5′ 3″ | 9 | 0.750 | 29-7/16″ | 4-7/16″ | 15-7/16″ | 21-7/16″ | 3.78 |
| 24×24 | 5′ 6″ | 9½ | 0.792 | 32-7/16″ | 4-7/16″ | 17-7/16″ | 23-7/16″ | 3.96 |
| 25×25 | 5′ 9″ | 9¾ | 0.813 | 35-7/16″ | 5-7/16″ | 18-7/16″ | 26-7/16″ | 4.17 |
| 26×26 | 6′ 0″ | 10 | 0.833 | 39-7/16″ | 5-7/16″ | 21-7/16″ | 29-7/16″ | 4.36 |

Superimposed load = 150 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 7 | 0.583 | 20-⅜″ | 4-⅜″ | 11-⅜″ | 14-⅜″ | 2.83 |
| 17×17 | 3′ 9″ | 7¼ | 0.605 | 23-⅜″ | 4-⅜″ | 12-⅜″ | 17-⅜″ | 2.98 |
| 18×18 | 4′ 0″ | 7¾ | 0.646 | 26-⅜″ | 4-⅜″ | 14-⅜″ | 19-⅜″ | 3.14 |
| 19×19 | 4′ 3″ | 8¼ | 0.688 | 21-7/16″ | 4-7/16″ | 12-7/16″ | 15-7/16″ | 3.27 |
| 20×20 | 4′ 6″ | 8½ | 0.709 | 24-7/16″ | 4-7/16″ | 13-7/16″ | 18-7/16″ | 3.48 |
| 21×21 | 4′ 9″ | 9 | 0.750 | 26-7/16″ | 6-7/16″ | 15-7/16″ | 20-7/16″ | 3.78 |
| 22×22 | 5′ 0″ | 9½ | 0.792 | 29-7/16″ | 5-7/16″ | 16-7/16″ | 21-7/16″ | 3.91 |
| 23×23 | 5′ 3″ | 9¾ | 0.813 | 32-7/16″ | 5-7/16″ | 18-7/16″ | 24-7/16″ | 4.16 |
| 24×24 | 5′ 6″ | 10¼ | 0.854 | 35-7/16″ | 6-7/16″ | 19-7/16″ | 26-7/16″ | 4.34 |
| 25×25 | 5′ 9″ | 10½ | 0.875 | 39-7/16″ | 5-7/16″ | 21-7/16″ | 28-7/16″ | 4.51 |
| 26×26 | 6′ 0″ | 11 | 0.917 | 42-7/16″ | 6-7/16″ | 24-7/16″ | 31-7/16″ | 4.76 |

Superimposed load = 200 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 7½ | 0.625 | 22-⅜″ | 5-⅜″ | 12-⅜″ | 17-⅜″ | 3.12 |
| 17×17 | 3′ 9″ | 8 | 0.667 | 25-⅜″ | 5-⅜″ | 14-⅜″ | 19-⅜″ | 3.29 |
| 18×18 | 4′ 0″ | 8½ | 0.708 | 29-⅜″ | 5-⅜″ | 16-⅜″ | 21-⅜″ | 3.49 |
| 19×19 | 4′ 3″ | 9 | 0.750 | 23-7/16″ | 5-7/16″ | 13-7/16″ | 17-7/16″ | 3.66 |
| 20×20 | 4′ 6″ | 9½ | 0.791 | 26-7/16″ | 4-7/16″ | 14-7/16″ | 19-7/16″ | 3.88 |
| 21×21 | 4′ 9″ | 10 | 0.833 | 29-7/16″ | 5-7/16″ | 16-7/16″ | 21-7/16″ | 4.04 |
| 22×22 | 5′ 0″ | 10½ | 0.875 | 32-7/16″ | 4-7/16″ | 17-7/16″ | 23-7/16″ | 4.20 |
| 23×23 | 5′ 3″ | 11¼ | 0.938 | 34-7/16″ | 5-7/16″ | 19-7/16″ | 25-7/16″ | 4.37 |
| 24×24 | 5′ 6″ | 12 | 1.000 | 38-7/16″ | 4-7/16″ | 21-7/16″ | 28-7/16″ | 4.64 |
| 25×25 | 5′ 9″ | 12¾ | 1.063 | 41-7/16″ | 4-7/16″ | 23-7/16″ | 30-7/16″ | 4.78 |
| 26×26 | 6′ 0″ | 13¼ | 1.142 | 47-7/16″ | 5-7/16″ | 26-7/16″ | 34-7/16″ | 5.23 |

# FLAT SLAB FLOORS
# AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS
# INTERIOR SQUARE PANELS

## CAP CONSTRUCTION

$f_c = 650$ *for positive moment*
$f_c = 750$ *for negative moment*
$f_s = 16{,}000$
$n = 15$

Superimposed load = 250 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 8¾ | 0.730 | 21-3/8″ | 6-3/8″ | 11-3/8″ | 16-3/8″ | 3.00 |
| 17×17 | 3′ 9″ | 9¼ | 0.771 | 26 -3/8″ | 4-3/8″ | 14 3/8″ | 19-3/8″ | 3.30 |
| 18×18 | 4′ 0″ | 10 | 0.833 | 29-3/8″ | 4-3/8″ | 16 3/8″ | 23-3/8″ | 3.61 |
| 19×19 | 4′ 3″ | 10¾ | 0.896 | 23 7/16″ | 4-7/16″ | 13 -7/16″ | 17 7/16″ | 3.64 |
| 20×20 | 4′ 6″ | 11½ | 0.959 | 26 7/16″ | 4-7/16″ | 15 7/16″ | 19 7/16″ | 3.91 |
| 21×21 | 4′ 9″ | 12 | 1.000 | 28 7/16″ | 2-7/16″ | 15 7/16″ | 20-7/16″ | 3.84 |
| 22×22 | 5′ 0″ | 13 | 1.083 | 31-7/16″ | 4-7/16″ | 17 7/16″ | 23 -7/16″ | 4.16 |
| 23×23 | 5′ 3″ | 13¾ | 1.146 | 34-7/16″ | 5-7/16″ | 19-7/16″ | 25-7/16″ | 4.37 |
| 24×24 | 5′ 6″ | 14¼ | 1.188 | 38 -7/16″ | 4-7/16″ | 21 7/16″ | 28-7/16″ | 4.65 |
| 25×25 | 5′ 9″ | 15 | 1.250 | 41 7/16″ | 5-7/16″ | 23-7/16″ | 30-7/16″ | 4.81 |
| 26×26 | 6′ 0″ | 15¾ | 1.313 | 45 7/16″ | 4-7/16″ | 25 7/16″ | 33-7/16″ | 5.03 |

Superimposed load = 300 lb. per sq. ft.

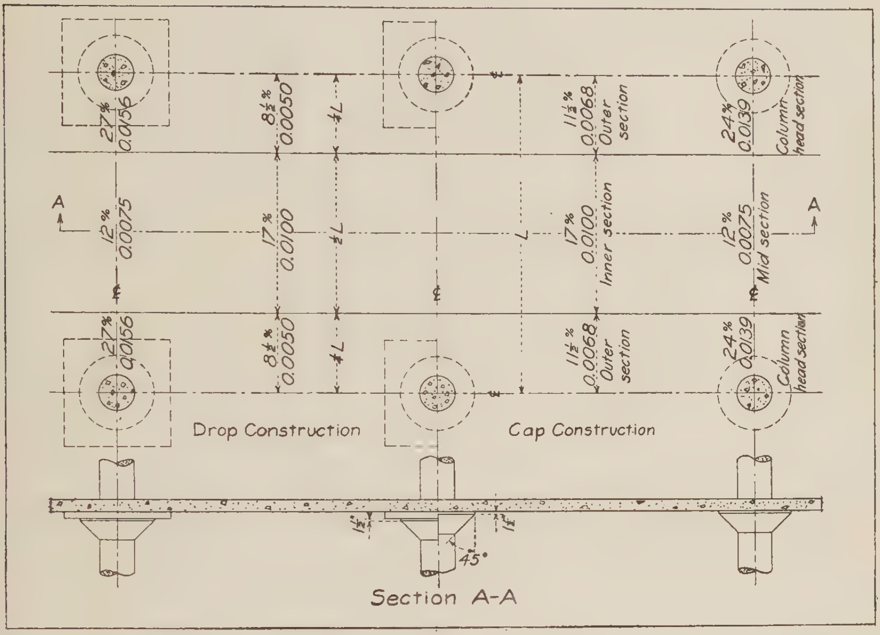
| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 10 | 0.833 | 23-3/8″ | 3 -3/8″ | 13-3/8″ | 17-3/8″ | 3.17 |
| 17×17 | 3′ 9″ | 10¾ | 0.896 | 26 3/8″ | 2 3/8″ | 14-3/8″ | 19 -3/8″ | 3.27 |
| 18×18 | 4′ 0″ | 11½ | 0.958 | 29 3/8″ | 3-3/8″ | 16 3/8″ | 21 3/8″ | 3.45 |
| 19×19 | 4′ 3″ | 12½ | 1.042 | 32-3/8″ | 2-3/8″ | 18 3/8″ | 23 -3/8″ | 3.58 |
| 20×20 | 4′ 6″ | 13 | 1.083 | 27 7/16″ | 3-7/16″ | 15-7/16″ | 19-7/16″ | 3.88 |
| 21×21 | 4′ 9″ | 14 | 1.174 | 29 7/16″ | 3 -7/16″ | 16 -7/16″ | 21-7/16″ | 4.02 |
| 22×22 | 5′ 0″ | 15 | 1.250 | 32 7/16″ | 2-7/16″ | 18 -7/16″ | 23-7/16″ | 4.20 |
| 23×23 | 5′ 3″ | 16 | 1.333 | 34 7/16″ | 4 -7/16″ | 19 7/16″ | 25-7/16″ | 4.33 |
| 24×24 | 5′ 6″ | 16½ | 1.375 | 38-7/16″ | 4 7/16″ | 21-7/16″ | 28-7/16″ | 4.64 |
| 25×25 | 5′ 9″ | 17 | 1.417 | 42-7/16″ | 4 7/16″ | 24 7/16″ | 31 7/16″ | 4.76 |
| 26×26 | 6′ 0″ | 18 | 1.500 | 46 7/16″ | 3 7/16″ | 25 7/16″ | 30-7/16″ | 4.84 |

Superimposed load = 350 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 11½ | 0.958 | 23 3/8″ | 2-3/8″ | 13-3/8″ | 17 3/8″ | 3.16 |
| 17×17 | 3′ 9″ | 12¼ | 1.021 | 26-3/8″ | 2-3/8″ | 14 3/8″ | 19-3/8″ | 3.23 |
| 18×18 | 4′ 0″ | 13 | 1.083 | 29 3/8″ | 3-3/8″ | 16-3/8″ | 21-3/8″ | 3.45 |
| 19×19 | 4′ 3″ | 13¾ | 1.146 | 33 3/8″ | 3-3/8″ | 18-3/8″ | 24-3/8″ | 3.74 |
| 20×20 | 4′ 6″ | 14¾ | 1.230 | 27-7/16″ | 2-7/16″ | 14 7/16″ | 19-7/16″ | 3.85 |
| 21×21 | 4′ 9″ | 15¾ | 1.313 | 29 7/16″ | 3-7/16″ | 16-7/16″ | 21-7/16″ | 4.02 |
| 22×22 | 5′ 0″ | 16¾ | 1.396 | 32-7/16″ | 3-7/16″ | 18-8/16″ | 23-7/16″ | 4.22 |
| 23×23 | 5′ 3″ | 17¾ | 1.480 | 35 7/16″ | 3-7/16″ | 20 -7/16″ | 26-7/16″ | 4.48 |
| 24×24 | 5′ 6″ | 18¾ | 1.563 | 37-7/16″ | 3-7/16″ | 21-7/16″ | 27-7/16″ | 4.50 |
| 25×25 | 5′ 9″ | 19¾ | 1.646 | 41-7/16″ | 4-7/16″ | 23 -7/16″ | 30-7/16″ | 4.79 |
| 26×26 | 6′ 0″ | 20¾ | 1.730 | 45 7/16″ | 3-7/16″ | 25-7/16″ | 33-7/16″ | 5.00 |

# FLAT SLAB FLOORS
# NEW YORK CITY BUILDING CODE
# INTERIOR SQUARE PANELS

$f_c = 650$ *for positive moment*
$f_c = 750$ *for negative moment*
$f_s = 16{,}000$
$n = 15$



## Bending Moment Coefficients

Moment coefficients shown on diagram are to be multiplied by $WL$.

$W = wL^2$

$w$ = total dead and live load in pounds per square foot.

$L$ = span center to center of columns for square panels, or average span for rectangular panels where long dimension is not more than 1.1 times short dimension.

Values shown above coefficients are percentages of numerical sum of moments in one direction across panel.

Numerical sum of moments in one direction across panel = $0.0587WL$.

Minimum size of drop = $0.33L$.

Minimum diameter of capital = $0.225L$.

$$\text{Minimum } t = \begin{cases} 6 \\ 0.02L\sqrt{w} + 1 \text{ with drop} \\ 0.024L\sqrt{w} + 1\tfrac{1}{2} \text{ without drop} \\ L/32 \end{cases} \quad (t \text{ in inches, } L \text{ in feet})$$

$t$ = total thickness of slab.

**FLAT SLABS**

# FLAT SLAB FLOORS
# NEW YORK CITY BUILDING CODE
# INTERIOR SQUARE PANELS

## DROP CONSTRUCTION

$f_c = 650$ *for positive moment*
$f_c = 750$ *for negative moment*
$f_s = 16{,}000$
$n = 15$

Superimposed load = 100 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band |  |  | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | Direct | Across direct | Diagonal |  |
| 16×16 | 3′ 6″ | 5′ 4″ | 6 | 3 | 0.528 | 13-⅜″ | 9-⅜″ | 9-⅜″ | 1.76 |
| 17×17 | 3′ 9″ | 5′ 8″ | 6½ | 3 | 0.570 | 15-⅜″ | 11-⅜″ | 10-⅜″ | 1.89 |
| 18×18 | 4′ 0″ | 6′ 0″ | 6¾ | 3¼ | 0.593 | 17-⅜″ | 12 ⅜″ | 12-⅜″ | 2.04 |
| 19×19 | 4′ 3″ | 6′ 4″ | 7¼ | 3½ | 0.636 | 19-⅜″ | 14-⅜″ | 13-⅜″ | 2.14 |
| 20×20 | 4′ 6″ | 6′ 8″ | 7½ | 3¾ | 0.660 | 21-⅜″ | 16-⅜″ | 15-⅜″ | 2.30 |
| 21×21 | 4′ 9″ | 7′ 0″ | 8 | 4 | 0.704 | 23-⅜″ | 17-⅜″ | 17-⅜″ | 2.40 |
| 22×22 | 5′ 0″ | 7′ 4″ | 8¼ | 4 | 0.725 | 26-⅜″ | 19 ⅜″ | 19-⅜″ | 2.57 |
| 23×23 | 5′ 3″ | 7′ 8″ | 8¾ | 4¼ | 0.770 | 22-7/16″ | 16-7/16″ | 16-7/16″ | 2.85 |
| 24×24 | 5′ 6″ | 8′ 0″ | 9 | 4¾ | 0.794 | 24-7/16″ | 18 7/16″ | 17-7/16″ | 2.95 |
| 25×25 | 5′ 9″ | 8′ 4″ | 9½ | 4¾ | 0.835 | 26-7/16″ | 19-7/16″ | 19-7/16″ | 3.10 |
| 26×26 | 6′ 0″ | 8′ 8″ | 9¾ | 5 | 0.858 | 29-7/16″ | 21-7/16″ | 21-7/16″ | 3.30 |

Superimposed load = 150 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band |  |  | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | Direct | Across direct | Diagonal |  |
| 16×16 | 3′ 6″ | 5′ 4″ | 6 | 3 | 0.528 | 16-⅜″ | 12-⅜″ | 12-⅜″ | 2.24 |
| 17×17 | 3′ 9″ | 5′ 8″ | 6½ | 3¼ | 0.571 | 18-⅜″ | 13 ⅜″ | 13-⅜″ | 2.32 |
| 18×18 | 4′ 0″ | 6′ 0″ | 6¾ | 3½ | 0.595 | 20-⅜″ | 15-⅜″ | 15-⅜″ | 2.48 |
| 19×19 | 4′ 3″ | 6′ 4″ | 7¼ | 4 | 0.641 | 22-⅜″ | 17-⅜″ | 16-⅜″ | 2.54 |
| 20×20 | 4′ 6″ | 6′ 8″ | 7½ | 4 | 0.662 | 25-⅜″ | 19-⅜″ | 19-⅜″ | 2.62 |
| 21×21 | 4′ 9″ | 7′ 0″ | 8 | 4¼ | 0.706 | 27-⅜″ | 20 ⅜″ | 20-⅜″ | 2.82 |
| 22×22 | 5′ 0″ | 7′ 4″ | 8¼ | 4¼ | 0.727 | 23-7/16″ | 17-7/16″ | 17-7/16″ | 3.15 |
| 23×23 | 5′ 3″ | 7′ 8″ | 8¾ | 4¾ | 0.774 | 25-7/16″ | 19-7/16″ | 18-7/16″ | 3.24 |
| 24×24 | 5′ 6″ | 8′ 0″ | 9¼ | 5 | 0.817 | 27-7/16″ | 20-7/16″ | 20-7/16″ | 3.36 |
| 25×25 | 5′ 9″ | 8′ 4″ | 9½ | 5½ | 0.841 | 30-7/16″ | 22-7/16″ | 22-7/16″ | 3.58 |
| 26×26 | 6′ 0″ | 8′ 8″ | 10 | 5¾ | 0.887 | 32-7/16″ | 24-7/16″ | 24-7/16″ | 3.72 |

Superimposed load = 200 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band |  |  | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | Direct | Across direct | Diagonal |  |
| 16×16 | 3′ 6″ | 5′ 4″ | 6½ | 3¼ | 0.571 | 18-⅜″ | 13-⅜″ | 13-⅜″ | 2.46 |
| 17×17 | 3′ 9″ | 5′ 8″ | 7 | 3¾ | 0.618 | 20 ⅜″ | 15 ⅜″ | 14-⅜″ | 2.54 |
| 18×18 | 4′ 0″ | 6′ 0″ | 7¼ | 4¼ | 0.643 | 22-⅜″ | 17-⅜″ | 16-⅜″ | 2.67 |
| 19×19 | 4′ 3″ | 6′ 4″ | 7¾ | 4¼ | 0.685 | 24-⅜″ | 18-⅜″ | 18-⅜″ | 2.80 |
| 20×20 | 4′ 6″ | 6′ 8″ | 8¼ | 4½ | 0.729 | 20-7/16″ | 15-7/16″ | 15 7/16″ | 3.04 |
| 21×21 | 4′ 9″ | 7′ 0″ | 8¾ | 5 | 0.775 | 22 7/16″ | 17 7/16″ | 16-7/16″ | 3.14 |
| 22×22 | 5′ 0″ | 7′ 4″ | 9 | 5¼ | 0.799 | 25-7/16″ | 19-7/16″ | 18-7/16″ | 3.38 |
| 23×23 | 5′ 3″ | 7′ 8″ | 9½ | 5¼ | 0.841 | 27 7/16″ | 21-7/16″ | 20-7/16″ | 3.54 |
| 24×24 | 5′ 6″ | 8′ 0″ | 10 | 5¾ | 0.887 | 29-7/16″ | 22-7/16″ | 22-7/16″ | 3.66 |
| 25×25 | 5′ 9″ | 8′ 4″ | 10¾ | 6¼ | 0.954 | 31-7/16″ | 24-7/16″ | 23-7/16″ | 3.77 |
| 26×26 | 6′ 0″ | 8′ 8″ | 11¼ | 6¾ | 1.002 | 34 7/16″ | 26-7/16″ | 25-7/16″ | 3.94 |

TABLE 10

# FLAT SLAB FLOORS
# NEW YORK CITY BUILDING CODE
# INTERIOR SQUARE PANELS

## DROP CONSTRUCTION

$f_c = 650$ *for positive moment*
$f_c = 750$ *for negative moment*
$f_s = 16{,}000$
$n = 15$

Superimposed load = 250 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″ | 7½ | 4 | 0.662 | 17–3/8″ | 13–3/8″ | 13–3/8″ | 2.39 |
| 17×17 | 3′ 9″ | 5′ 8″ | 8 | 4¼ | 0.706 | 20–3/8″ | 15–3/8″ | 15–3/8″ | 2.62 |
| 18×18 | 4′ 0″ | 6′ 0″ | 8½ | 4¾ | 0.752 | 22–3/8″ | 17–3/8″ | 17–3/8″ | 2.76 |
| 19×19 | 4′ 3″ | 6′ 4″ | 9 | 5 | 0.797 | 25–3/8″ | 19–3/8″ | 18–3/8″ | 2.87 |
| 20×20 | 4′ 6″ | 6′ 8″ | 9¾ | 5 | 0.859 | 21–7/16″ | 15–7/16″ | 15–7/16″ | 3.11 |
| 21×21 | 4′ 9″ | 7′ 0″ | 10¼ | 5½ | 0.906 | 23–7/16″ | 17–7/16″ | 17–7/16″ | 3.29 |
| 22×22 | 5′ 0″ | 7′ 4″ | 10¾ | 6 | 0.953 | 25–7/16″ | 19–7/16″ | 18–7/16″ | 3.38 |
| 23×23 | 5′ 3″ | 7′ 8″ | 11½ | 6 | 1.014 | 27–7/16″ | 20–7/16″ | 20–7/16″ | 3.51 |
| 24×24 | 5′ 6″ | 8′ 0″ | 12 | 6½ | 1.060 | 30–7/16″ | 22–7/16″ | 22–7/16″ | 3.71 |
| 25×25 | 5′ 9″ | 8′ 4″ | 12¾ | 7¼ | 1.129 | 32–7/16″ | 24–7/16″ | 23–7/16″ | 3.80 |
| 26×26 | 6′ 0″ | 8′ 8″ | 13¾ | 7½ | 1.215 | 27–1/2″ | 20–1/2″ | 19–1/2″ | 3.98 |

Superimposed load = 300 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″ | 8½ | 4½ | 0.749 | 18–3/8″ | 13–3/8″ | 13–3/8″ | 2.46 |
| 17×17 | 3′ 9″ | 5′ 8″ | 9 | 5 | 0.796 | 20–3/8″ | 15–3/8″ | 15–3/8″ | 2.62 |
| 18×18 | 4′ 0″ | 6′ 0″ | 9¾ | 5 | 0.858 | 22–3/8″ | 17–3/8″ | 16–3/8″ | 2.67 |
| 19×19 | 4′ 3″ | 6′ 4″ | 10½ | 5¾ | 0.928 | 25–3/8″ | 19–3/8″ | 18–3/8″ | 2.87 |
| 20×20 | 4′ 6″ | 6′ 8″ | 11¼ | 6¼ | 0.996 | 20–7/16″ | 15–7/16″ | 15–7/16″ | 3.04 |
| 21×21 | 4′ 9″ | 7′ 0″ | 11¾ | 6¾ | 1.043 | 22–7/16″ | 17–7/16″ | 16–7/16″ | 3.14 |
| 22×22 | 5′ 0″ | 7′ 4″ | 12½ | 6¾ | 1.104 | 25–7/16″ | 18–7/16″ | 18–7/16″ | 3.36 |
| 23×23 | 5′ 3″ | 7′ 8″ | 13¼ | 7¼ | 1.169 | 27–7/16″ | 20–7/16″ | 20–7/16″ | 3.51 |
| 24×24 | 5′ 6″ | 8′ 0″ | 13¾ | 7½ | 1.215 | 30–7/16″ | 22–7/16″ | 22–7/16″ | 3.71 |
| 25×25 | 5′ 9″ | 8′ 4″ | 14½ | 8 | 1.283 | 32–7/16″ | 24–7/16″ | 23–7/16″ | 3.80 |
| 26×26 | 6′ 0″ | 8′ 8″ | 15½ | 9 | 1.375 | 26–1/2″ | 19–1/2″ | 19–1/2″ | 3.90 |

Superimposed load = 350 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″ | 9½ | 5 | 0.827 | 18–3/8″ | 13–3/8″ | 13–3/8″ | 2.46 |
| 17×17 | 3′ 9″ | 5′ 8″ | 10 | 5¼ | 0.882 | 21–3/8″ | 15–3/8″ | 15–3/8″ | 2.68 |
| 18×18 | 4′ 0″ | 6′ 0″ | 10¾ | 6 | 0.951 | 23–3/8″ | 17–3/8″ | 16–3/8″ | 2.74 |
| 19×19 | 4′ 3″ | 6′ 4″ | 11½ | 6¼ | 1.017 | 26–3/8″ | 19–3/8″ | 18–3/8″ | 2.90 |
| 20×20 | 4′ 6″ | 6′ 8″ | 12½ | 6½ | 1.101 | 21–7/16″ | 15–7/16″ | 15–7/16″ | 3.11 |
| 21×21 | 4′ 9″ | 7′ 0″ | 13¼ | 7¼ | 1.169 | 23–7/16″ | 17–7/16″ | 16–7/16″ | 3.21 |
| 22×22 | 5′ 0″ | 7′ 4″ | 14 | 7¾ | 1.239 | 25–7/16″ | 19–7/16″ | 18–7/16″ | 3.38 |
| 23×23 | 5′ 3″ | 7′ 8″ | 15 | 8 | 1.324 | 28–7/16″ | 20–7/16″ | 19–7/16″ | 3.49 |
| 24×24 | 5′ 6″ | 8′ 0″ | 15¾ | 8¾ | 1.393 | 30–7/16″ | 22–7/16″ | 21–7/16″ | 3.64 |
| 25×25 | 5′ 9″ | 8′ 4″ | 16¾ | 9¼ | 1.483 | 32–7/16″ | 24–7/16″ | 23–7/16″ | 3.80 |
| 26×26 | 6′ 0″ | 8′ 8″ | 17¾ | 9¾ | 1.569 | 27–1/2″ | 20–1/2″ | 19–1/2″ | 3.98 |

# FLAT SLAB FLOORS
# NEW YORK CITY BUILDING CODE
# INTERIOR SQUARE PANELS

## CAP CONSTRUCTION

$f_c = 650$ *for positive moment*
$f_c = 750$ *for negative moment*
$f_s = 16{,}000$
$n = 15$

Superimposed load = 100 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 6¾ | 0.562 | 14-⅜″ | 8-⅜″ | 8-⅜″ | 8-⅜″ | 1.91 |
| 17×17 | 3′ 9″ | 7¼ | 0.605 | 16-⅜″ | 10-⅜″ | 9-⅜″ | 9-⅜″ | 2.04 |
| 18×18 | 4′ 0″ | 7¾ | 0.645 | 18-⅜″ | 11-⅜″ | 10-⅜″ | 10-⅜″ | 2.14 |
| 19×19 | 4′ 3″ | 8 | 0.667 | 21-⅜″ | 11-⅜″ | 12-⅜″ | 12-⅜″ | 2.34 |
| 20×20 | 4′ 6″ | 8½ | 0.708 | 23-⅜″ | 13-⅜″ | 13-⅜″ | 13-⅜″ | 2.44 |
| 21×21 | 4′ 9″ | 9 | 0.750 | 19-7/16″ | 10-7/16″ | 11-7/16″ | 11-7/16″ | 2.66 |
| 22×22 | 5′ 0″ | 9½ | 0.791 | 21-7/16″ | 11-7/16″ | 12-7/16″ | 12-7/16″ | 2.78 |
| 23×23 | 5′ 3″ | 10 | 0.833 | 24-7/16″ | 12-7/16″ | 13-7/16″ | 13-7/16″ | 2.95 |
| 24×24 | 5′ 6″ | 10½ | 0.875 | 26-7/16″ | 14-7/16″ | 15-7/16″ | 14-7/16″ | 3.08 |
| 25×25 | 5′ 9″ | 11 | 0.917 | 29-7/16″ | 15-7/16″ | 16-7/16″ | 15-7/16″ | 3.22 |
| 26×26 | 6′ 0″ | 11¼ | 0.937 | 32-7/16″ | 16-7/16″ | 18-7/16″ | 18-7/16″ | 3.56 |

Superimposed load = 150 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 7¾ | 0.645 | 16-⅜″ | 8-⅜″ | 9-⅜″ | 9-⅜″ | 2.12 |
| 17×17 | 3′ 9″ | 8¼ | 0.687 | 18-⅜″ | 10-⅜″ | 10-⅜″ | 10-⅜″ | 2.25 |
| 18×18 | 4′ 0″ | 8½ | 0.708 | 21-⅜″ | 11-⅜″ | 12-⅜″ | 12-⅜″ | 2.48 |
| 19×19 | 4′ 3″ | 9 | 0.750 | 24-⅜″ | 13-⅜″ | 13-⅜″ | 13-⅜″ | 2.62 |
| 20×20 | 4′ 6″ | 9½ | 0.792 | 20-7/16″ | 10-7/16″ | 11-7/16″ | 11-7/16″ | 2.85 |
| 21×21 | 4′ 9″ | 10 | 0.833 | 22-7/16″ | 12-7/16″ | 12-7/16″ | 12-7/16″ | 2.99 |
| 22×22 | 5′ 0″ | 10½ | 0.875 | 25-7/16″ | 13-7/16″ | 14-7/16″ | 13-7/16″ | 3.20 |
| 23×23 | 5′ 3″ | 11 | 0.917 | 27-7/16″ | 15-7/16″ | 15-7/16″ | 14-7/16″ | 3.30 |
| 24×24 | 5′ 6″ | 11½ | 0.958 | 23-½″ | 12-½″ | 13-½″ | 13-½″ | 3.60 |
| 25×25 | 5′ 9″ | 12 | 1.000 | 26-½″ | 12-½″ | 14-½″ | 14-½″ | 3.78 |
| 26×26 | 6′ 0″ | 12½ | 1.042 | 28-½″ | 14-½″ | 15-½″ | 15-½″ | 3.93 |

Superimposed load = 200 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 8¼ | 0.687 | 18-⅜″ | 10-⅜″ | 10-⅜″ | 10-⅜″ | 2.39 |
| 17×17 | 3′ 9″ | 8¾ | 0.729 | 21-⅜″ | 11-⅜″ | 12-⅜″ | 11-⅜″ | 2.55 |
| 18×18 | 4′ 0″ | 9¼ | 0.771 | 18-7/16″ | 10-7/16″ | 10-7/16″ | 9-7/16″ | 2.72 |
| 19×19 | 4′ 3″ | 9¾ | 0.812 | 19-7/16″ | 11-7/16″ | 11-7/16″ | 11-7/16″ | 2.96 |
| 20×20 | 4′ 6″ | 10¼ | 0.855 | 22-7/16″ | 12-7/16″ | 12-7/16″ | 12-7/16″ | 3.27 |
| 21×21 | 4′ 9″ | 10¾ | 0.896 | 25-7/16″ | 13-7/16″ | 14-7/16″ | 13-7/16″ | 3.34 |
| 22×22 | 5′ 0″ | 11½ | 0.958 | 21-½″ | 11-½″ | 12-½″ | 11-½″ | 3.52 |
| 23×23 | 5′ 3″ | 12 | 1.000 | 23-½″ | 12-½″ | 13-½″ | 12-½″ | 3.61 |
| 24×24 | 5′ 6″ | 12½ | 1.042 | 25-½″ | 13-½″ | 14-½″ | 14-½″ | 3.90 |
| 25×25 | 5′ 9″ | 13 | 1.083 | 28-½″ | 14-½″ | 15-½″ | 15-½″ | 4.09 |
| 26×26 | 6′ 0″ | 13¾ | 1.145 | 30-½″ | 16-½″ | 17-½″ | 16-½″ | 4.25 |

TABLE 11

# FLAT SLAB FLOORS
# NEW YORK CITY BUILDING CODE
# INTERIOR SQUARE PANELS

## CAP CONSTRUCTION

$f_c = 650$ *for positive moment*
$f_c = 750$ *for negative moment*
$f_s = 16{,}000$
$n = 15$

Superimposed load = 250 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 9 | 0.750 | 19-3/8″ | 10-3/8″ | 11-3/8″ | 11-3/8″ | 2.53 |
| 17×17 | 3′ 9″ | 9½ | 0.791 | 17-7/16″ | 9-7/16″ | 9-7/16″ | 9-7/16″ | 2.75 |
| 18×18 | 4′ 0″ | 10 | 0.833 | 19-7/16″ | 10-7/16″ | 11-7/16″ | 10-7/16″ | 3.01 |
| 19×19 | 4′ 3″ | 10½ | 0.875 | 21-7/16″ | 11-7/16″ | 12-7/16″ | 12-7/16″ | 3.21 |
| 20×20 | 4′ 6″ | 11¼ | 0.937 | 23-7/16″ | 12-7/16″ | 13-7/16″ | 13-7/16″ | 3.32 |
| 21×21 | 4′ 9″ | 11¾ | 0.979 | 20-1/2″ | 11-1/2″ | 11-1/2″ | 11-1/2″ | 3.57 |
| 22×22 | 5′ 0″ | 12½ | 1.042 | 22-1/2″ | 12-1/2″ | 12-1/2″ | 12-1/2″ | 3.74 |
| 23×23 | 5′ 3″ | 13¼ | 1.104 | 24-1/2″ | 13-1/2″ | 13-1/2″ | 13-1/2″ | 3.87 |
| 24×24 | 5′ 6″ | 14 | 1.167 | 26-1/2″ | 13-1/2″ | 15-1/2″ | 15-1/2″ | 4.08 |
| 25×25 | 5′ 9″ | 14¾ | 1.229 | 29-1/2″ | 14-1/2″ | 16-1/2″ | 16-1/2″ | 4.27 |
| 26×26 | 6′ 0″ | 15½ | 1.292 | 31-1/2″ | 14-1/2″ | 17-1/2″ | 17-1/2″ | 4.36 |

Superimposed load = 300 lb. per sq. ft.

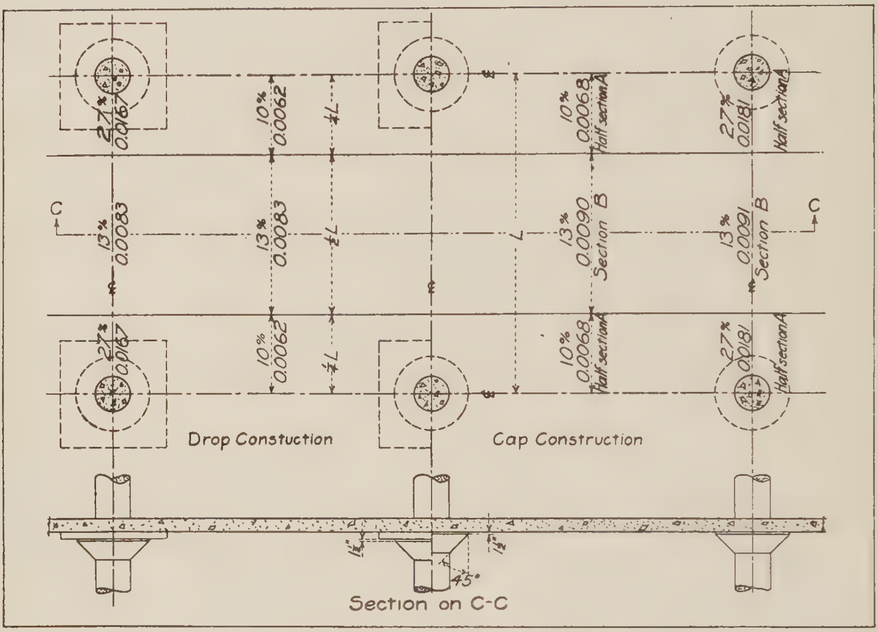
| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 10¼ | 0.854 | 19-3/8″ | 10-3/8″ | 11-3/8″ | 11-3/8″ | 2.53 |
| 17×17 | 3′ 9″ | 11 | 0.917 | 17-7/16″ | 8-7/16″ | 9-7/16″ | 9-7/16″ | 2.81 |
| 18×18 | 4′ 0″ | 11½ | 0.958 | 19-7/16″ | 9-7/16″ | 10-7/16″ | 10-7/16″ | 2.95 |
| 19×19 | 4′ 3″ | 12¼ | 1.021 | 21-7/16″ | 11-7/16″ | 12-7/16″ | 11-7/16″ | 3.12 |
| 20×20 | 4′ 6″ | 13 | 1.083 | 23-7/16″ | 11-7/16″ | 13-7/16″ | 13-7/16″ | 3.29 |
| 21×21 | 4′ 9″ | 13¾ | 1.146 | 20-1/2″ | 10-1/2″ | 11-1/2″ | 11-1/2″ | 3.55 |
| 22×22 | 5′ 0″ | 14½ | 1.208 | 22-1/2″ | 11-1/2″ | 12-1/2″ | 12-1/2″ | 3.69 |
| 23×23 | 5′ 3″ | 15¼ | 1.271 | 24-1/2″ | 12-1/2″ | 14-1/2″ | 13-1/2″ | 3.87 |
| 24×24 | 5′ 6″ | 16 | 1.333 | 27-1/2″ | 13-1/2″ | 15-1/2″ | 14-1/2″ | 4.07 |
| 25×25 | 5′ 9″ | 17 | 1.417 | 29-1/2″ | 13-1/2″ | 16-1/2″ | 16-1/2″ | 4.22 |
| 26×26 | 6′ 0″ | 18 | 1.500 | 31-1/2″ | 14-1/2″ | 17-1/2″ | 17-1/2″ | 4.36 |

Superimposed load = 350 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Direct over column, add'l each way | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 11½ | 0.958 | 20-3/8″ | 9-3/8″ | 11-3/8″ | 11-3/8″ | 2.58 |
| 17×17 | 3′ 9″ | 12¼ | 1.021 | 17-7/16″ | 8-7/16″ | 9-7/16″ | 9-7/16″ | 2.81 |
| 18×18 | 4′ 0″ | 13 | 1.083 | 19-7/16″ | 9-7/16″ | 10-7/16″ | 10-7/16″ | 2.95 |
| 19×19 | 4′ 3″ | 13¾ | 1.146 | 21-7/16″ | 10-7/16″ | 12-7/16″ | 12-7/16″ | 3.18 |
| 20×20 | 4′ 6″ | 14¾ | 1.229 | 23-7/16″ | 11-7/16″ | 13-7/16″ | 13-7/16″ | 3.29 |
| 21×21 | 4′ 9″ | 15½ | 1.292 | 20-1/2″ | 9-1/2″ | 11-1/2″ | 11-1/2″ | 3.52 |
| 22×22 | 5′ 0″ | 16½ | 1.375 | 22-1/2″ | 10-1/2″ | 12-1/2″ | 12-1/2″ | 3.69 |
| 23×23 | 5′ 3″ | 17¼ | 1.437 | 24-1/2″ | 11-1/2″ | 14-1/2″ | 13-1/2″ | 3.84 |
| 24×24 | 5′ 6″ | 18¼ | 1.521 | 27-1/2″ | 12-1/2″ | 15-1/2″ | 14-1/2″ | 4.11 |
| 25×25 | 5′ 9″ | 19¼ | 1.604 | 29-1/2″ | 12-1/2″ | 16-1/2″ | 16-1/2″ | 4.22 |
| 26×26 | 6′ 0″ | 20 | 1.667 | 32-1/2″ | 14-1/2″ | 17-1/2″ | 17-1/2″ | 4.41 |

## FLAT SLAB FLOORS
## CHICAGO BUILDING CODE
## INTERIOR SQUARE PANELS

***$f_c = 700$ for positive moment***
***$f_c = 805$ for negative moment***
***$f_s = 18{,}000$***
***$n = 15$***



**Bending Moment Coefficients**

Moment coefficients shown on diagram are to be multiplied by $WL$.

$W = wL^2$
$w$ = total dead and live load in pounds per square foot.
$L$ = span center to center of columns for square panels, or average span for rectangular panels where long dimension is not more than 1.05 times short dimension.

Values shown above moment coefficients are percentages of numerical sum of moments in one direction across panel.

Numerical sum of moments in one direction across panel:
for drop construction $0.0625WL$
for cap construction $0.0679WL$

Minimum size of drop = $\frac{1}{3}L$
Minimum diameter of capital = $0.225L$

$$\text{Minimum } t = \begin{cases} 6 \\ \sqrt{W}/44 \\ L/32 \end{cases}$$

$t$ = total thickness of slab.
$t$ is in inches, $L$ is in feet.

TABLE 12

# FLAT SLAB FLOORS CHICAGO BUILDING CODE INTERIOR SQUARE PANELS

## DROP CONSTRUCTION

$f_c = 700$ *for positive moment*
$f_c = 805$ *for negative moment*
$f_s = 18,000$
$n = 15$

Superimposed load = 100 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″×5′ 4″ | 6 | 3½ | 0.54 | 13–⅜″ | 9–⅜″ | 10–⅜″ | 1.83 |
| 17×17 | 3′ 9″ | 5′ 8″×5′ 8″ | 6½ | 3¾ | 0.58 | 15–⅜″ | 10–⅜″ | 11–⅜″ | 1.94 |
| 18×18 | 4′ 0″ | 6′ 0″×6′ 0″ | 6¾ | 4¼ | 0.60 | 17–⅜″ | 11–⅜″ | 12–⅜″ | 2.04 |
| 19×19 | 4′ 3″ | 6′ 4″×6′ 4″ | 7¼ | 4¼ | 0.65 | 19–⅜″ | 13–⅜″ | 14–⅜″ | 2.19 |
| 20×20 | 4′ 6″ | 6′ 8″×6′ 8″ | 7½ | 4½ | 0.67 | 22–⅜″ | 14–⅜″ | 16–⅜″ | 2.35 |
| 21×21 | 4′ 9″ | 7′ 0″×7′ 0″ | 8 | 4¾ | 0.72 | 24–⅜″ | 16–⅜″ | 17–⅜″ | 2.45 |
| 22×22 | 5′ 0″ | 7′ 4″×7′ 4″ | 8¼ | 5 | 0.74 | 27–⅜″ | 18–⅜″ | 19–⅜″ | 2.63 |
| 23×23 | 5′ 3″ | 7′ 8″×7′ 8″ | 8¾ | 5½ | 0.78 | 22–7⁄16″ | 14–7⁄16″ | 16–7⁄16″ | 2.81 |
| 24×24 | 5′ 6″ | 8′ 0″×8′ 0″ | 9 | 5¾ | 0.81 | 25–7⁄16″ | 16–7⁄16″ | 17–7⁄16″ | 2.99 |
| 25×25 | 5′ 9″ | 8′ 4″×8′ 4″ | 9½ | 6 | 0.85 | 27–7⁄16″ | 17–7⁄16″ | 18–7⁄16″ | 3.04 |
| 26×26 | 6′ 0″ | 8′ 8″×8′ 8″ | 9¾ | 6 | 0.87 | 30–7⁄16″ | 20–7⁄16″ | 21–7⁄16″ | 3.33 |

Superimposed load = 150 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″×5′ 4″ | 6 | 3¾ | 0.54 | 17–⅜″ | 11–⅜″ | 12–⅜″ | 2.31 |
| 17×17 | 3′ 9″ | 5′ 8″×5′ 8″ | 6½ | 3¾ | 0.58 | 19–⅜″ | 13–⅜″ | 14–⅜″ | 2.46 |
| 18×18 | 4′ 0″ | 6′ 0″×6′ 0″ | 6¾ | 4 | 0.61 | 21–⅜″ | 15–⅜″ | 16–⅜″ | 2.63 |
| 19×19 | 4′ 3″ | 6′ 4″×6′ 4″ | 7¼ | 4¼ | 0.65 | 25–⅜″ | 17–⅜″ | 18–⅜″ | 2.84 |
| 20×20 | 4′ 6″ | 6′ 8″×6′ 8″ | 7½ | 4¾ | 0.67 | 27–⅜″ | 18–⅜″ | 20–⅜″ | 2.95 |
| 21×21 | 4′ 9″ | 7′ 0″×7′ 0″ | 8 | 5 | 0.72 | 30–⅜″ | 20–⅜″ | 22–⅜″ | 3.09 |
| 22×22 | 5′ 0″ | 7′ 4″×7′ 4″ | 8¼ | 5¼ | 0.74 | 25–7⁄16″ | 16–7⁄16″ | 17–7⁄16″ | 3.23 |
| 23×23 | 5′ 3″ | 7′ 8″×7′ 8″ | 8¾ | 5¾ | 0.79 | 28–7⁄16″ | 17–7⁄16″ | 18–7⁄16″ | 3.33 |
| 24×24 | 5′ 6″ | 8′ 0″×8′ 0″ | 9 | 5¾ | 0.81 | 30–7⁄16″ | 20–7⁄16″ | 21–7⁄16″ | 3.56 |
| 25×25 | 5′ 9″ | 8′ 4″×8′ 4″ | 9½ | 6 | 0.85 | 34–7⁄16″ | 22–7⁄16″ | 23–7⁄16″ | 3.83 |
| 26×26 | 6′ 0″ | 8′ 8″×8′ 8″ | 10 | 6 | 0.89 | 36–7⁄16″ | 24–7⁄16″ | 25–7⁄16″ | 3.94 |

Superimposed load = 200 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″×5′ 4″ | 6¼ | 3¾ | 0.56 | 21–⅜″ | 13–⅜″ | 14–⅜″ | 2.74 |
| 17×17 | 3′ 9″ | 5′ 8″×5′ 8″ | 6½ | 3¾ | 0.58 | 24–⅜″ | 16–⅜″ | 17–⅜″ | 3.01 |
| 18×18 | 4′ 0″ | 6′ 0″×6′ 0″ | 7 | 4¼ | 0.62 | 27–⅜″ | 18–⅜″ | 20–⅜″ | 3.25 |
| 19×19 | 4′ 3″ | 6′ 4″×6′ 4″ | 7½ | 4½ | 0.67 | 31–⅜″ | 21–⅜″ | 22–⅜″ | 3.47 |
| 20×20 | 4′ 6″ | 6′ 8″×6′ 8″ | 8 | 4¾ | 0.72 | 24–7⁄16″ | 17–7⁄16″ | 18–7⁄16″ | 3.52 |
| 21×21 | 4′ 9″ | 7′ 0″×7′ 0″ | 8½ | 5¼ | 0.76 | 26–7⁄16″ | 17–7⁄16″ | 18–7⁄16″ | 3.54 |
| 22×22 | 5′ 0″ | 7′ 4″×7′ 4″ | 9 | 5¾ | 0.80 | 28–7⁄16″ | 18–7⁄16″ | 20–7⁄16″ | 3.66 |
| 23×23 | 5′ 3″ | 7′ 8″×7′ 8″ | 9½ | 6 | 0.85 | 30–7⁄16″ | 20–7⁄16″ | 21–7⁄16″ | 3.71 |
| 24×24 | 5′ 6″ | 8′ 0″×8′ 0″ | 10 | 6¼ | 0.89 | 34–7⁄16″ | 22–7⁄16″ | 24–7⁄16″ | 4.03 |
| 25×25 | 5′ 9″ | 8′ 4″×8′ 4″ | 10½ | 6½ | 0.94 | 37–7⁄16″ | 24–7⁄16″ | 25–7⁄16″ | 4.13 |
| 26×26 | 6′ 0″ | 8′ 8″×8′ 8″ | 11 | 6½ | 0.98 | 39–7⁄16″ | 28–7⁄16″ | 29–7⁄16″ | 4.39 |

TABLE 12

## FLAT SLAB FLOORS
## CHICAGO BUILDING CODE
## INTERIOR SQUARE PANELS

### DROP CONSTRUCTION

$f_c = 700$ *for positive moment*
$f_c = 805$ *for negative moment*
$f_s = 18{,}000$
$n = 15$

Superimposed load = 250 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″×5′ 4″ | 6¾ | 4¼ | 0.60 | 23-⅜″ | 14-⅜″ | 16-⅜″ | 3.03 |
| 17×17 | 3′ 9″ | 5′ 8″×5′ 8″ | 7¼ | 4¼ | 0.65 | 24-⅜″ | 17-⅜″ | 18-⅜″ | 3.12 |
| 18×18 | 4′ 0″ | 6′ 0″×6′ 0″ | 7¾ | 4¾ | 0.69 | 27-⅜″ | 18-⅜″ | 19-⅜″ | 3.21 |
| 19×19 | 4′ 3″ | 6′ 4″×6′ 4″ | 8¼ | 5¼ | 0.74 | 30-⅜″ | 20-⅜″ | 21-⅜″ | 3.33 |
| 20×20 | 4′ 6″ | 6′ 8″×6′ 8″ | 8¾ | 5¼ | 0.78 | 25-7/16″ | 17-7/16″ | 18-7/16″ | 3.63 |
| 21×21 | 4′ 9″ | 7′ 0″×7′ 0″ | 9¼ | 5¾ | 0.82 | 27-7/16″ | 18-7/16″ | 20-7/16″ | 3.77 |
| 22×22 | 5′ 0″ | 7′ 4″×7′ 4″ | 9¾ | 6 | 0.87 | 30-7/16″ | 20-7/16″ | 21-7/16″ | 3.91 |
| 23×23 | 5′ 3″ | 7′ 8″×7′ 8″ | 10¼ | 6¼ | 0.92 | 33-7/16″ | 22-7/16″ | 24-7/16″ | 4.16 |
| 24×24 | 5′ 6″ | 8′ 0″×8′ 0″ | 10¾ | 6¾ | 0.96 | 37-7/16″ | 24-7/16″ | 25-7/16″ | 4.31 |
| 25×25 | 5′ 9″ | 8′ 4″×8′ 4″ | 11½ | 7¼ | 1.03 | 39-7/16″ | 25-7/16″ | 27-7/16″ | 4.41 |
| 26×26 | 6′ 0″ | 8′ 8″×8′ 8″ | 12 | 7½ | 1.08 | 42-7/16″ | 28-7/16″ | 30-7/16″ | 4.63 |

Superimposed load = 300 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″×5′ 4″ | 7¼ | 4¼ | 0.65 | 24-⅜″ | 16-⅜″ | 17-⅜″ | 3.20 |
| 17×17 | 3′ 9″ | 5′ 8″×5′ 8″ | 8 | 4¾ | 0.72 | 27-⅜″ | 17-⅜″ | 18-⅜″ | 3.28 |
| 18×18 | 4′ 0″ | 6′ 0″×6′ 0″ | 8½ | 5¼ | 0.77 | 21-7/16″ | 14-7/16″ | 16-7/16″ | 3.49 |
| 19×19 | 4′ 3″ | 6′ 4″×6′ 4″ | 9 | 5½ | 0.81 | 24-7/16″ | 16-7/16″ | 17-7/16″ | 3.66 |
| 20×20 | 4′ 6″ | 6′ 8″×6′ 8″ | 9½ | 6 | 0.85 | 27-7/16″ | 18-7/16″ | 19-7/16″ | 3.85 |
| 21×21 | 4′ 9″ | 7′ 0″×7′ 0″ | 10 | 6¼ | 0.89 | 30-7/16″ | 20-7/16″ | 21-7/16″ | 4.09 |
| 22×22 | 5′ 0″ | 7′ 4″×7′ 4″ | 10½ | 6¼ | 0.94 | 33-7/16″ | 21-7/16″ | 22-7/16″ | 4.20 |
| 23×23 | 5′ 3″ | 7′ 8″×7′ 8″ | 11 | 7 | 0.99 | 35-7/16″ | 23-7/16″ | 25-7/16″ | 4.40 |
| 24×24 | 5′ 6″ | 8′ 0″×8′ 0″ | 11¾ | 7¼ | 1.05 | 39-7/16″ | 25-7/16″ | 26-7/16″ | 4.55 |
| 25×25 | 5′ 9″ | 8′ 4″×8′ 4″ | 12¼ | 7¾ | 1.10 | 33-½″ | 22-½″ | 23-½″ | 4.78 |
| 26×26 | 6′ 0″ | 8′ 8″×8′ 8″ | 12¾ | 8 | 1.15 | 35-½″ | 25-½″ | 26-½″ | 5.15 |

Superimposed load = 350 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Size of drop panel | Depth of slab (inches) | Depth of drop (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 5′ 4″×5′ 4″ | 8 | 4½ | 0.71 | 24-⅜″ | 16-⅜″ | 17-⅜″ | 3.20 |
| 17×17 | 3′ 9″ | 5′ 8″×5′ 8″ | 8½ | 5¼ | 0.76 | 27-⅜″ | 18-⅜″ | 19-⅜″ | 3.36 |
| 18×18 | 4′ 0″ | 6′ 0″×6′ 0″ | 9 | 5½ | 0.80 | 23-7/16″ | 15-7/16″ | 16-7/16″ | 3.64 |
| 19×19 | 4′ 3″ | 6′ 4″×6′ 4″ | 9½ | 6 | 0.84 | 25-7/16″ | 17-7/16″ | 18-7/16″ | 3.82 |
| 20×20 | 4′ 6″ | 6′ 8″×6′ 8″ | 10 | 6½ | 0.89 | 27-7/16″ | 19-7/16″ | 20-7/16″ | 4.00 |
| 21×21 | 4′ 9″ | 7′ 0″×7′ 0″ | 10¾ | 6½ | 0.95 | 31-7/16″ | 20-7/16″ | 22-7/16″ | 4.24 |
| 22×22 | 5′ 0″ | 7′ 4″×7′ 4″ | 11¼ | 6¾ | 1.00 | 34-7/16″ | 22-7/16″ | 24-7/16″ | 4.42 |
| 23×23 | 5′ 3″ | 7′ 8″×7′ 8″ | 12 | 7 | 1.07 | 37-7/16″ | 25-7/16″ | 26-7/16″ | 4.63 |
| 24×24 | 5′ 6″ | 8′ 0″×8′ 0″ | 12½ | 7¾ | 1.12 | 30-½″ | 20-½″ | 22-½″ | 4.76 |
| 25×25 | 5′ 9″ | 8′ 4″×8′ 4″ | 13 | 8 | 1.16 | 34-½″ | 23-½″ | 23-½″ | 5.00 |
| 26×26 | 6′ 0″ | 8′ 8″×8′ 8″ | 13¾ | 8½ | 1.22 | 38-½″ | 25-½″ | 26-½″ | 5.29 |

# FLAT SLAB FLOORS
# CHICAGO BUILDING CODE
# INTERIOR SQUARE PANELS

## CAP CONSTRUCTION

$f_c = 700$ *for positive moment*
$f_c = 805$ *for negative moment*
$f_s = 18{,}000$
$n = 15$

Superimposed load = 100 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Add'l in each band over each column | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 6¾ | 0.562 | 13-⅜″ | 8-⅜″ | 9-⅜″ | 9-⅜″ | 2.17 |
| 17×17 | 3′ 9″ | 7¼ | 0.604 | 14-⅜″ | 10-⅜″ | 10-⅜″ | 10-⅜″ | 2.34 |
| 18×18 | 4′ 0″ | 7¾ | 0.646 | 16-⅜″ | 11-⅜″ | 11-⅜″ | 11-⅜″ | 2.46 |
| 19×19 | 4′ 3″ | 8 | 0.667 | 19-⅜″ | 12-⅜″ | 13-⅜″ | 13-⅜″ | 2.69 |
| 20×20 | 4′ 6″ | 8½ | 0.708 | 21-⅜″ | 14-⅜″ | 14-⅜″ | 14-⅜″ | 2.85 |
| 21×21 | 4′ 9″ | 9 | 0.750 | 17-7/16″ | 11-7/16″ | 12-7/16″ | 12-7/16″ | 3.04 |
| 22×22 | 5′ 0″ | 9½ | 0.792 | 19-7/16″ | 13-7/16″ | 13-7/16″ | 13-7/16″ | 3.23 |
| 23×23 | 5′ 3″ | 9¾ | 0.812 | 21-7/16″ | 15-7/16″ | 14-7/16″ | 14-7/16″ | 3.40 |
| 24×24 | 5′ 6″ | 10¼ | 0.854 | 24-7/16″ | 16-7/16″ | 16-7/16″ | 16-7/16″ | 3.65 |
| 25×25 | 5′ 9″ | 10¾ | 0.896 | 26-7/16″ | 17-7/16″ | 18-7/16″ | 18-7/16″ | 3.85 |
| 26×26 | 6′ 0″ | 11¼ | 0.937 | 28-7/16″ | 19-7/16″ | 19-7/16″ | 19-7/16″ | 3.97 |

Superimposed load = 150 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Add'l in each band over each column | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 7½ | 0.625 | 15-⅜″ | 10-⅜″ | 10-⅜″ | 10-⅜″ | 2.50 |
| 17×17 | 3′ 9″ | 8 | 0.667 | 17-⅜″ | 11-⅜″ | 11-⅜″ | 11-⅜″ | 2.65 |
| 18×18 | 4′ 0″ | 8½ | 0.708 | 19-⅜″ | 12-⅜″ | 13-⅜″ | 13-⅜″ | 2.83 |
| 19×19 | 4′ 3″ | 9 | 0.750 | 21-⅜″ | 14-⅜″ | 14-⅜″ | 14-⅜″ | 2.96 |
| 20×20 | 4′ 6″ | 9¼ | 0.771 | 24-⅜″ | 16-⅜″ | 17-⅜″ | 17-⅜″ | 3.32 |
| 21×21 | 4′ 9″ | 10 | 0.833 | 20-7/16″ | 13-7/16″ | 13-7/16″ | 13-7/16″ | 3.46 |
| 22×22 | 5′ 0″ | 10½ | 0.875 | 22-7/16″ | 14-7/16″ | 15-7/16″ | 15-7/16″ | 3.67 |
| 23×23 | 5′ 3″ | 11 | 0.917 | 24-7/16″ | 16-7/16″ | 16-7/16″ | 16-7/16″ | 3.83 |
| 24×24 | 5′ 6″ | 11½ | 0.958 | 26-7/16″ | 17-7/16″ | 18-7/16″ | 18-7/16″ | 3.96 |
| 25×25 | 5′ 9″ | 12 | 1.000 | 29-7/16″ | 19-7/16″ | 20-7/16″ | 20-7/16″ | 4.26 |
| 26×26 | 6′ 0″ | 12½ | 1.042 | 25-½″ | 16-½″ | 17-½″ | 17-½″ | 4.54 |

Superimposed load = 200 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Add'l in each band over each column | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 8¼ | 0.687 | 16-⅜″ | 11-⅜″ | 11-⅜″ | 11-⅜″ | 2.76 |
| 17×17 | 3′ 9″ | 8¾ | 0.729 | 18-⅜″ | 12-⅜″ | 13-⅜″ | 13-⅜″ | 2.95 |
| 18×18 | 4′ 0″ | 9¼ | 0.771 | 15-7/16″ | 10-7/16″ | 11-7/16″ | 11-7/16″ | 3.21 |
| 19×19 | 4′ 3″ | 9¾ | 0.813 | 17-7/16″ | 12-7/16″ | 12-7/16″ | 12-7/16″ | 3.42 |
| 20×20 | 4′ 6″ | 10¼ | 0.854 | 20-7/16″ | 13-7/16″ | 13-7/16″ | 13-7/16″ | 3.60 |
| 21×21 | 4′ 9″ | 10¾ | 0.896 | 22-7/16″ | 14-7/16″ | 15-7/16″ | 15-7/16″ | 3.82 |
| 22×22 | 5′ 0″ | 11¼ | 0.937 | 24-7/16″ | 16-7/16″ | 16-7/16″ | 16-7/16″ | 4.00 |
| 23×23 | 5′ 3″ | 12 | 1.000 | 20-½″ | 13-½″ | 14-½″ | 14-½″ | 4.21 |
| 24×24 | 5′ 6″ | 12½ | 1.042 | 23-½″ | 14-½″ | 15-½″ | 15-½″ | 4.46 |
| 25×25 | 5′ 9″ | 13 | 1.083 | 25-½″ | 16-½″ | 17-½″ | 17-½″ | 4.76 |
| 26×26 | 6′ 0″ | 13½ | 1.125 | 27-½″ | 18-½″ | 18-½″ | 18-½″ | 4.94 |

TABLE 13

# FLAT SLAB FLOORS
# CHICAGO BUILDING CODE
# INTERIOR SQUARE PANELS

## CAP CONSTRUCTION

$f_c = 700$ *for positive moment*
$f_c = 805$ *for negative moment*
$f_s = 18{,}000$
$n = 15$

Superimposed load = 250 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lbs. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Add'l in each band over each column | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 9 | 0.750 | 17–⅜″ | 11–⅜″ | 12–⅜″ | 12–⅜″ | 2.92 |
| 17×17 | 3′ 9″ | 9½ | 0.792 | 20–⅜″ | 13–⅜″ | 13–⅜″ | 13–⅜″ | 3.12 |
| 18×18 | 4′ 0″ | 10 | 0.833 | 17–7/16″ | 11–7/16″ | 11–7/16″ | 11–7/16″ | 3.42 |
| 19×19 | 4′ 3″ | 10¾ | 0.896 | 19–7/16″ | 12–7/16″ | 13–7/16″ | 13–7/16″ | 3.67 |
| 20×20 | 4′ 6″ | 11¼ | 0.937 | 21–7/16″ | 14–7/16″ | 14–7/16″ | 14–7/16″ | 3.86 |
| 21×21 | 4′ 9″ | 11¾ | 0.979 | 23–7/16″ | 15–7/16″ | 16–7/16″ | 16–7/16″ | 4.05 |
| 22×22 | 5′ 0″ | 12½ | 1.042 | 20–½″ | 13–½″ | 13–½″ | 13–½″ | 4.29 |
| 23×23 | 5′ 3″ | 13¼ | 1.104 | 21–½″ | 14–½″ | 15–½″ | 15–½″ | 4.51 |
| 24×24 | 5′ 6″ | 14 | 1.167 | 24–½″ | 15–½″ | 16–½″ | 16 ½″ | 4.71 |
| 25×25 | 5′ 9″ | 14½ | 1.208 | 26–½″ | 16–½″ | 17–½″ | 17–½″ | 4.91 |
| 26×26 | 6′ 0″ | 15¼ | 1.271 | 28–½″ | 18–½″ | 19–½″ | 19–½″ | 5.13 |

Superimposed load = 300 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Add'l in each band over each column | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 10¼ | 0.854 | 18–⅜″ | 11–⅜″ | 12–⅜″ | 12–⅜″ | 3.01 |
| 17×17 | 3′ 9″ | 11 | 0.917 | 15–7/16″ | 9 7/16″ | 10–7/16″ | 10–7/16″ | 3.20 |
| 18×18 | 4′ 0″ | 11½ | 0.958 | 17–7/16″ | 11–7/16″ | 11–7/16″ | 11–7/16″ | 3.42 |
| 19×19 | 4′ 3″ | 12¼ | 1.021 | 19–7/16″ | 12–7/16″ | 13–7/16″ | 13–7/16″ | 3.67 |
| 20×20 | 4′ 6″ | 13 | 1.083 | 21–7/16″ | 13–7/16″ | 14–7/16″ | 14–7/16″ | 3.80 |
| 21×21 | 4′ 9″ | 13½ | 1.125 | 23–7/16″ | 15–7/16″ | 16–7/16″ | 16–7/16″ | 4.05 |
| 22×22 | 5′ 0″ | 14¼ | 1.187 | 20–½″ | 13–½″ | 13–½″ | 13–½″ | 4.27 |
| 23×23 | 5′ 3″ | 15 | 1.250 | 22–½″ | 14–½″ | 14–½″ | 14–½″ | 4.47 |
| 24×24 | 5′ 6″ | 16 | 1.333 | 24–½″ | 15–½″ | 16–½″ | 16–½″ | 4.71 |
| 25×25 | 5′ 9″ | 17 | 1.417 | 26–½″ | 16–½″ | 17–½″ | 17–½″ | 4.84 |
| 26×26 | 6′ 0″ | 17¾ | 1.479 | 28–½″ | 18–½″ | 19–½″ | 19–½″ | 5.13 |

Superimposed load = 350 lb. per sq. ft.

| Panel size (feet) | Capital diameter | Depth of slab (inches) | Concrete in cubic feet per sq. ft. | Round steel rods in each band | | | | Steel in lb. per sq. ft. |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct | Add'l in each band over each column | Across direct | Diagonal | |
| 16×16 | 3′ 6″ | 11½ | 0.958 | 18–⅜″ | 11–⅜″ | 12–⅜″ | 12–⅜″ | 3.01 |
| 17×17 | 3′ 9″ | 12¼ | 1.021 | 15 7/16″ | 10–7/16″ | 10–7/16″ | 10–7/16″ | 3.28 |
| 18×18 | 4′ 0″ | 13 | 1.083 | 17–7/16″ | 11–7/16″ | 11–7/16″ | 11–7/16″ | 3.42 |
| 19×19 | 4′ 3″ | 13¾ | 1.146 | 19–7/16″ | 12–7/16″ | 13–7/16″ | 13–7/16″ | 3.67 |
| 20×20 | 4′ 6″ | 14½ | 1.208 | 21–7/16″ | 14–7/16″ | 14–7/16″ | 14–7/16″ | 3.86 |
| 21×21 | 4′ 9″ | 15¼ | 1.271 | 23–7/16″ | 15–7/16″ | 16–7/16″ | 16–7/16″ | 4.05 |
| 22×22 | 5′ 0″ | 16¼ | 1.354 | 20–½″ | 13–½″ | 13–½″ | 13–½″ | 4.29 |
| 23×23 | 5′ 3″ | 17¼ | 1.437 | 22–½″ | 14–½″ | 14–½″ | 14–½″ | 4.47 |
| 24×24 | 5′ 6″ | 18¼ | 1.521 | 23–½″ | 15–½″ | 16–½″ | 16–½″ | 4.64 |
| 25×25 | 5′ 9″ | 19 | 1.583 | 26–½″ | 17–½″ | 17 ½″ | 17 ½″ | 4.91 |
| 26×26 | 6′ 0″ | 20 | 1.667 | 28–½″ | 18–½″ | 19–½″ | 19–½″ | 5.13 |

## SECTION 3

# RECTANGULAR BEAMS

Table 14 and Diagram 18 may be used in the design of rectangular beams. Diagram 18 may also be employed to determine the safe resisting moment of a given beam and the greatest unit stresses due to a given bending moment.

### Example of Design of Rectangular Beam

*Design a simply supported rectangular beam to carry a total load of* 3000 *lb. per ft. on a span of* 20 *ft.*; $f_c = 650$; $f_s = 16{,}000$; $n = 15$.

Reading from the intersection of lines representing $f_c = 650$ and $f_s = 16{,}000$ in Diagram 18, it is found that $\frac{M}{bd^2} = 107.5$ and $j = 0.875$ (Table 14 gives values of 107.7 and 0.874 respectively).

$$M = \frac{wl^2}{8} = \frac{(3000)(20)^2}{8}(12) = 1{,}800{,}000 \text{ in.-lb.}$$

$$bd^2 = \frac{M}{107.5} = 16{,}750$$

Assuming $b = 14$ in. $d = 34.5$ in.

$$A_s = \frac{M}{f_s jd} = \frac{1{,}800{,}000}{(16{,}000)(0.875)(34.5)} = 3.73 \text{ sq. in.}$$

$$\text{or } A_s = (0.0077)(14)(34.5) = 3.72 \text{ sq. in.}$$

From Table 15 which gives areas and perimeters of combinations of four rods, we find that the area of three 1⅛-in. and one 1-in. round rods is 3.77 sq. in.

To make a complete design, the bond stress and shearing stress should also be investigated.

### Reviewing Design of Rectangular Beam

*Given a beam* 12 *in. wide,* 30 *in. deep to steel, reinforced with four* 1*-in. round rods and subjected to a bending moment of* 1,500,000 *in.-lb. Find the unit stresses in the steel and concrete.* $n = 15$.

$$\frac{M}{bd^2} = \frac{1{,}500{,}000}{(12)(30)^2} = 139$$

$$p = \frac{A_s}{bd} = \frac{3.14}{(12)(30)} = 0.0087$$

From Diagram 18

$$f_c = 805 \text{ and } f_s = 18{,}200$$

### Using Diagrams for Rectangular Beams One Inch Wide

*Design a rectangular beam to resist a moment of* 1,000,000 *in.-lb., assuming* $f_c = 750$ *and* $f_s = 18{,}000$.

Taking $b = 12$ in., the bending moment per inch of width is

$$\frac{1{,}000{,}000}{12} = 83{,}333 \text{ in.-lb.}$$

Then from Diagram 24

$$d = 26 \text{ in. and } A_s = (12)(0.204) = 2.448 \text{ sq. in.}$$

### Finding Points to Bend Horizontal Steel

Diagram 25 is for use in determining the points at which horizontal steel in beams or slabs can be bent so that the steel remaining will not be less than that required to take the bending moment. The curves in the lower left hand corner are maximum bending moment curves for the center and supports of beams for different conditions of loading and restraint. They give the proportion of the steel required at different points along the beam from support to center.

*How far from the support of a simple beam of 20-ft. span, uniformly loaded, can four tenths* (0.4) *of the steel be bent up?*

Using the scale which reads up from the bottom, enter at 0.4 and follow horizontally to the curve marked "uniform load, simple span, bottom steel." The bend point is shown to be 0.183 of the span length from the support. Following up to the line for a 20-ft. span and then horizontally to the right hand scale, this distance is found to be 44 in. from the support.

TABLE 14

## VALUES OF *k*, *j*, *p* AND *K*

$$k=\frac{nf_c}{f_s+nf_c} \qquad j=1-\frac{k}{3} \qquad p=\frac{kf_c}{2f_s} \qquad K=\frac{M}{bd^2}=pf_sj=\frac{f_ckj}{2}$$

n = 12

| $f_s$ | $f_c$ | $k$ | $j$ | $p$ | $K$ | $f_s$ | $f_c$ | $k$ | $j$ | $p$ | $K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14,000 | 500 | 0.300 | 0.900 | 0.0054 | 67.5 | 17,000 | 500 | 0.261 | 0.913 | 0.0038 | 59.6 |
| | 550 | 0.320 | 0.893 | 0.0063 | 78.7 | | 550 | 0.280 | 0.907 | 0.0045 | 69.4 |
| | 600 | 0.340 | 0.887 | 0.0073 | 90.5 | | 600 | 0.298 | 0.901 | 0.0053 | 80.5 |
| | 650 | 0.358 | 0.881 | 0.0083 | 102.5 | | 650 | 0.315 | 0.895 | 0.0060 | 91.6 |
| | 700 | 0.375 | 0.875 | 0.0094 | 114.8 | | 700 | 0.331 | 0.890 | 0.0068 | 103.1 |
| | 750 | 0.391 | 0.870 | 0.0105 | 127.6 | | 750 | 0.346 | 0.885 | 0.0076 | 114.7 |
| | 800 | 0.407 | 0.864 | 0.0116 | 140.6 | | 800 | 0.361 | 0.880 | 0.0085 | 127.1 |
| | 850 | 0.421 | 0.860 | 0.0128 | 154.0 | | 850 | 0.375 | 0.875 | 0.0094 | 139.5 |
| | 900 | 0.435 | 0.855 | 0.0140 | 167.4 | | 900 | 0.389 | 0.870 | 0.0103 | 152.2 |
| 15,000 | 500 | 0.286 | 0.905 | 0.0048 | 64.7 | 18,000 | 500 | 0.250 | 0.917 | 0.0035 | 57.2 |
| | 550 | 0.306 | 0.898 | 0.0056 | 75.5 | | 550 | 0.268 | 0.911 | 0.0041 | 67.2 |
| | 600 | 0.324 | 0.892 | 0.0065 | 86.7 | | 600 | 0.286 | 0.905 | 0.0048 | 77.6 |
| | 650 | 0.342 | 0.887 | 0.0074 | 98.6 | | 650 | 0.302 | 0.899 | 0.0055 | 88.4 |
| | 700 | 0.359 | 0.880 | 0.0084 | 110.4 | | 700 | 0.318 | 0.894 | 0.0062 | 99.6 |
| | 750 | 0.375 | 0.875 | 0.0094 | 123.4 | | 750 | 0.333 | 0.889 | 0.0069 | 111.1 |
| | 800 | 0.390 | 0.870 | 0.0104 | 135.7 | | 800 | 0.348 | 0.884 | 0.0077 | 123.0 |
| | 850 | 0.405 | 0.865 | 0.0115 | 149.2 | | 850 | 0.362 | 0.879 | 0.0085 | 135.2 |
| | 900 | 0.418 | 0.861 | 0.0125 | 162.0 | | 900 | 0.375 | 0.875 | 0.0094 | 147.7 |
| 16,000 | 500 | 0.273 | 0.909 | 0.0043 | 62.0 | 20,000 | 500 | 0.231 | 0.923 | 0.0029 | 53.3 |
| | 550 | 0.292 | 0.903 | 0.0050 | 72.5 | | 550 | 0.248 | 0.917 | 0.0034 | 62.6 |
| | 600 | 0.310 | 0.897 | 0.0058 | 83.5 | | 600 | 0.265 | 0.912 | 0.0040 | 72.6 |
| | 650 | 0.328 | 0.891 | 0.0067 | 94.9 | | 650 | 0.281 | 0.906 | 0.0046 | 82.7 |
| | 700 | 0.344 | 0.885 | 0.0075 | 106.7 | | 700 | 0.296 | 0.901 | 0.0052 | 93.3 |
| | 750 | 0.360 | 0.880 | 0.0084 | 118.8 | | 750 | 0.310 | 0.897 | 0.0058 | 104.3 |
| | 800 | 0.375 | 0.875 | 0.0094 | 131.3 | | 800 | 0.324 | 0.892 | 0.0065 | 115.6 |
| | 850 | 0.389 | 0.870 | 0.0103 | 144.0 | | 850 | 0.338 | 0.887 | 0.0072 | 127.4 |
| | 900 | 0.403 | 0.866 | 0.0113 | 157.0 | | 900 | 0.351 | 0.883 | 0.0079 | 139.4 |

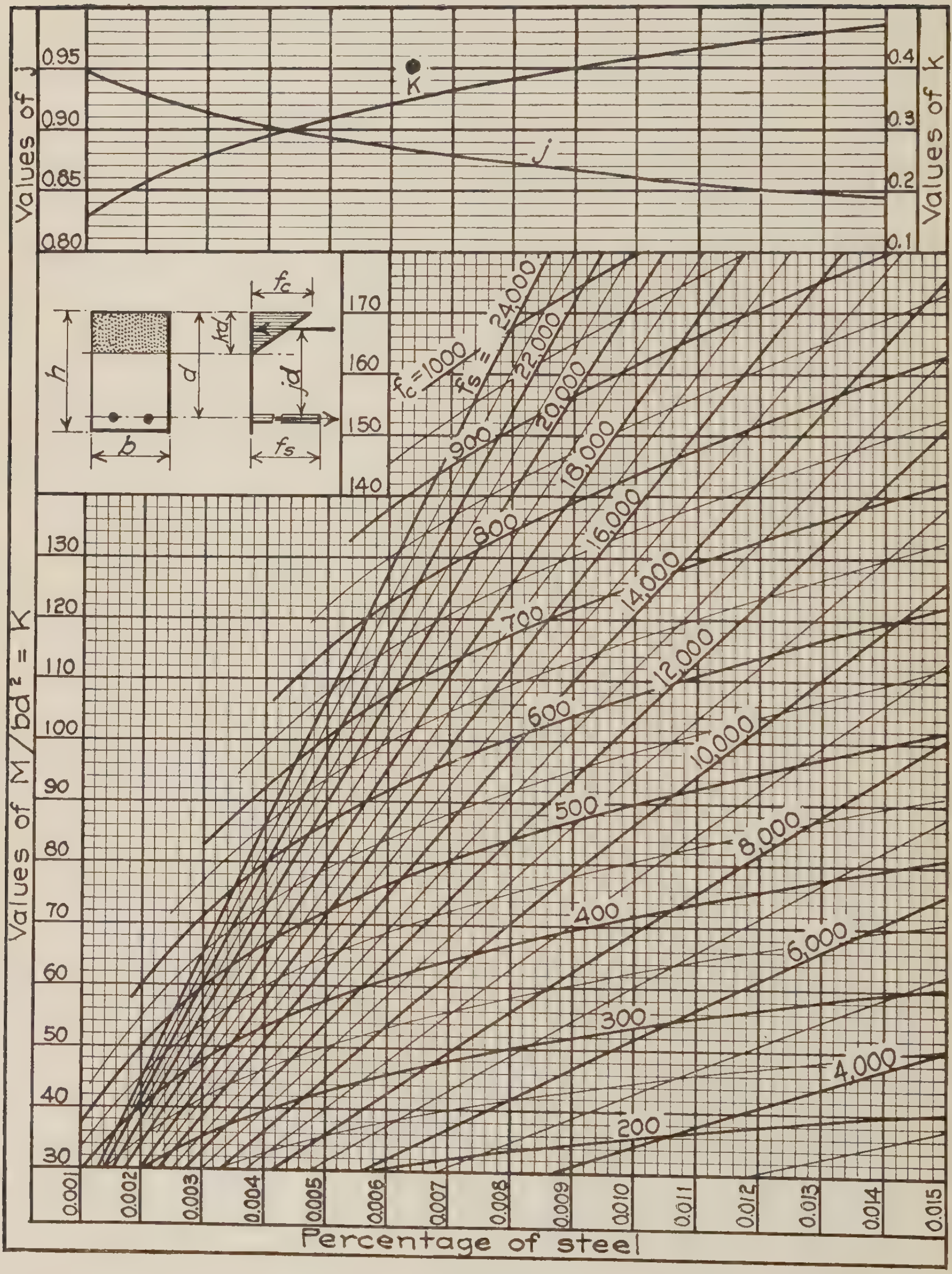
n = 15

| $f_s$ | $f_c$ | $k$ | $j$ | $p$ | $K$ | $f_s$ | $f_c$ | $k$ | $j$ | $p$ | $K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14,000 | 500 | 0.349 | 0.884 | 0.0062 | 77.1 | 17,000 | 500 | 0.306 | 0.898 | 0.0045 | 68.7 |
| | 550 | 0.371 | 0.876 | 0.0073 | 89.4 | | 550 | 0.327 | 0.891 | 0.0053 | 80.1 |
| | 600 | 0.391 | 0.870 | 0.0084 | 102.1 | | 600 | 0.346 | 0.885 | 0.0061 | 91.8 |
| | 650 | 0.411 | 0.863 | 0.0095 | 115.2 | | 650 | 0.365 | 0.878 | 0.0070 | 104.2 |
| | 700 | 0.429 | 0.857 | 0.0107 | 128.6 | | 700 | 0.382 | 0.873 | 0.0079 | 116.7 |
| | 750 | 0.446 | 0.851 | 0.0120 | 142.2 | | 750 | 0.398 | 0.866 | 0.0088 | 129.2 |
| | 800 | 0.462 | 0.846 | 0.0132 | 156.3 | | 800 | 0.414 | 0.862 | 0.0097 | 142.7 |
| | 850 | 0.477 | 0.841 | 0.0145 | 170.4 | | 850 | 0.429 | 0.857 | 0.0107 | 155.9 |
| | 900 | 0.491 | 0.836 | 0.0158 | 184.8 | | 900 | 0.443 | 0.853 | 0.0117 | 169.7 |
| 15,000 | 500 | 0.333 | 0.889 | 0.0056 | 74.1 | 18,000 | 500 | 0.294 | 0.902 | 0.0041 | 66.3 |
| | 550 | 0.355 | 0.882 | 0.0065 | 86.4 | | 550 | 0.314 | 0.895 | 0.0048 | 77.4 |
| | 600 | 0.375 | 0.875 | 0.0075 | 98.4 | | 600 | 0.333 | 0.889 | 0.0056 | 88.9 |
| | 650 | 0.394 | 0.869 | 0.0085 | 111.3 | | 650 | 0.351 | 0.883 | 0.0063 | 100.8 |
| | 700 | 0.412 | 0.863 | 0.0096 | 124.4 | | 700 | 0.368 | 0.877 | 0.0072 | 113.1 |
| | 750 | 0.428 | 0.857 | 0.0107 | 137.6 | | 750 | 0.385 | 0.872 | 0.0080 | 125.7 |
| | 800 | 0.444 | 0.852 | 0.0118 | 151.2 | | 800 | 0.400 | 0.867 | 0.0089 | 138.7 |
| | 850 | 0.460 | 0.847 | 0.0130 | 165.1 | | 850 | 0.415 | 0.862 | 0.0098 | 151.9 |
| | 900 | 0.474 | 0.842 | 0.0142 | 179.5 | | 900 | 0.429 | 0.857 | 0.0107 | 165.3 |
| 16,000 | 500 | 0.319 | 0.894 | 0.0050 | 71.3 | 20,000 | 500 | 0.273 | 0.909 | 0.0034 | 62.0 |
| | 550 | 0.339 | 0.887 | 0.0058 | 82.9 | | 550 | 0.292 | 0.903 | 0.0040 | 72.5 |
| | 600 | 0.360 | 0.880 | 0.0068 | 95.0 | | 600 | 0.310 | 0.897 | 0.0047 | 83.5 |
| | 650 | 0.379 | 0.874 | 0.0077 | 107.7 | | 650 | 0.328 | 0.891 | 0.0053 | 94.9 |
| | 700 | 0.396 | 0.868 | 0.0087 | 120.4 | | 700 | 0.344 | 0.885 | 0.0060 | 106.6 |
| | 750 | 0.413 | 0.862 | 0.0097 | 133.5 | | 750 | 0.360 | 0.880 | 0.0068 | 118.8 |
| | 800 | 0.429 | 0.857 | 0.0107 | 146.9 | | 800 | 0.375 | 0.875 | 0.0075 | 131.2 |
| | 850 | 0.443 | 0.852 | 0.0118 | 160.6 | | 850 | 0.389 | 0.870 | 0.0083 | 144.0 |
| | 900 | 0.458 | 0.847 | 0.0129 | 174.5 | | 900 | 0.403 | 0.866 | 0.0091 | 157.0 |

**RECTANGULAR BEAMS**

## VALUES OF *k*, *j*, *p* AND *K*

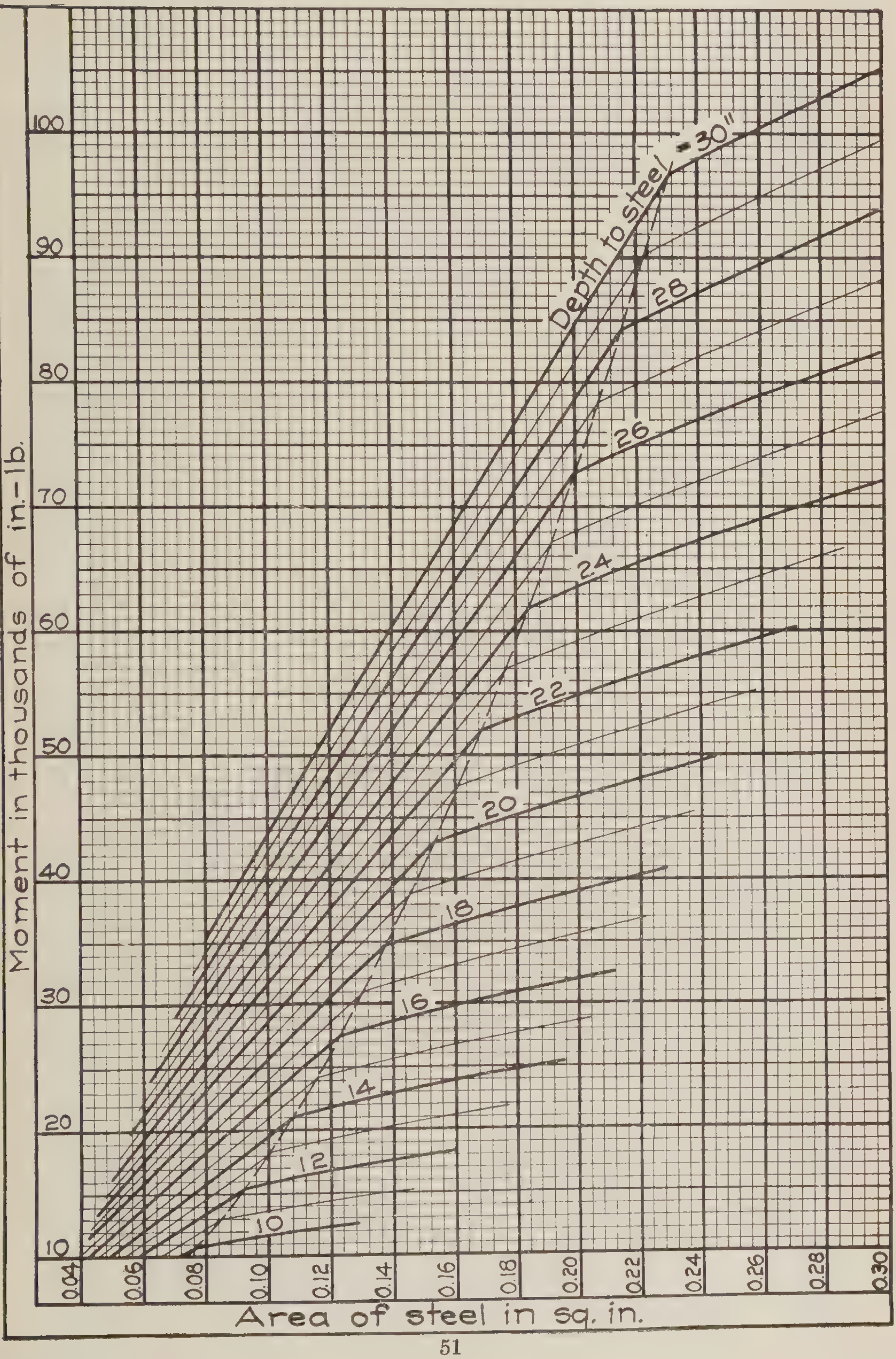
$n=15$



**RECTANGULAR BEAMS**

## MOMENT OF RESISTANCE AND AREA OF STEEL FOR BEAMS ONE INCH WIDE

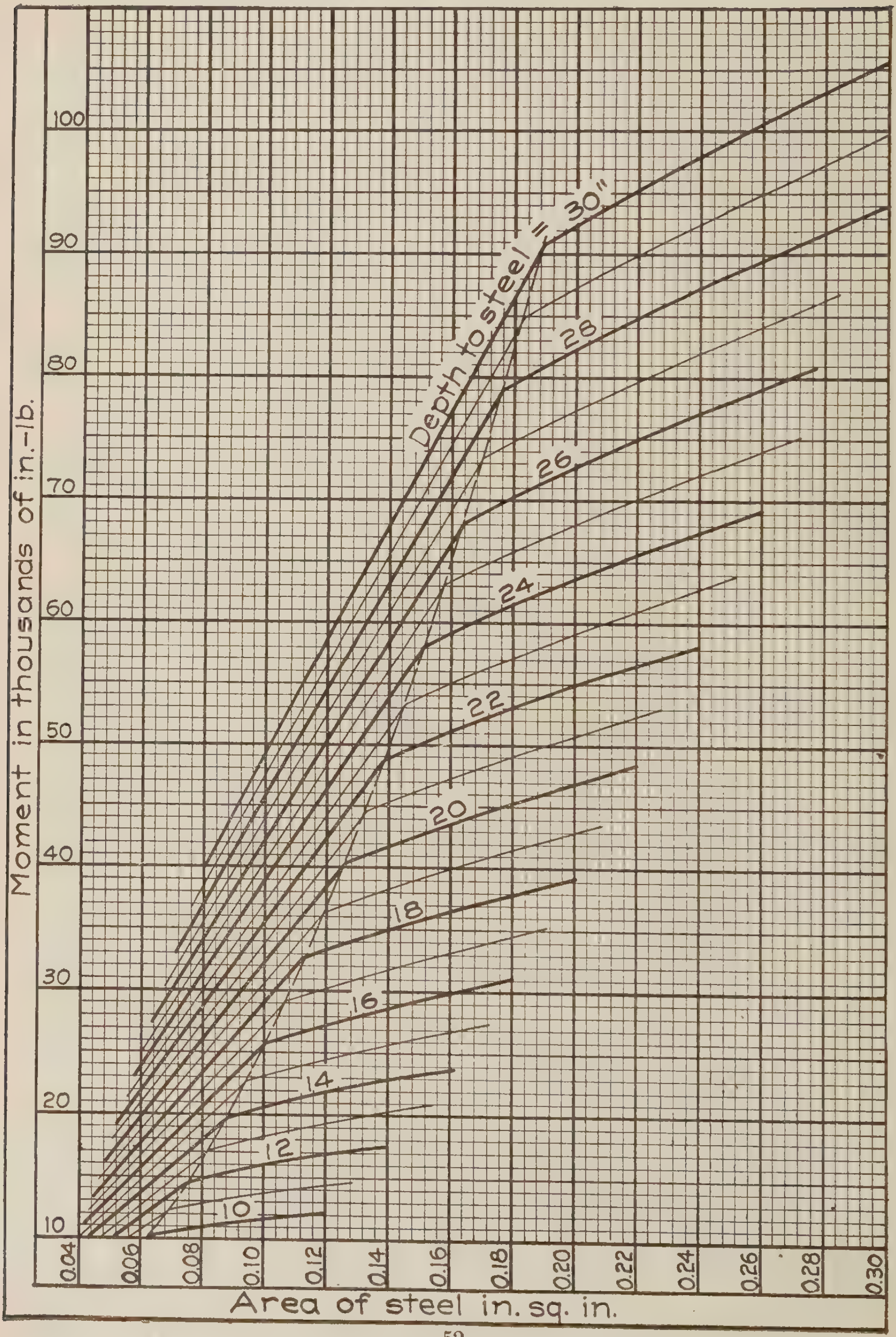
$f_c = 650$
$f_s = 16{,}000$
$n = 15$



## RECTANGULAR BEAMS

$f_c = 650$
$f_s = 18{,}000$
$n = 15$

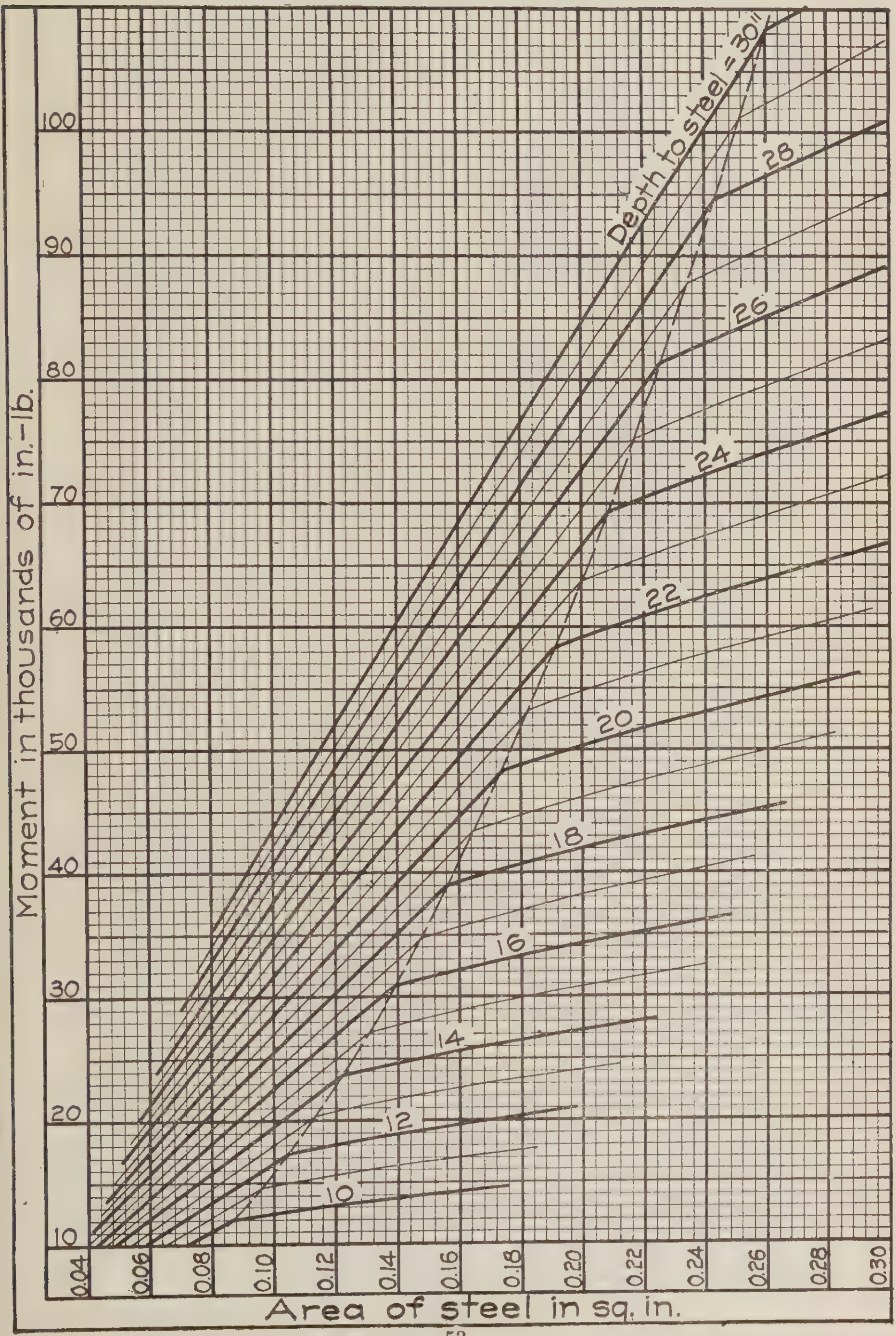
## MOMENT OF RESISTANCE AND AREA OF STEEL FOR BEAMS ONE INCH WIDE



RECTANGULAR
BEAMS

## MOMENT OF RESISTANCE AND AREA OF STEEL FOR BEAMS ONE INCH WIDE

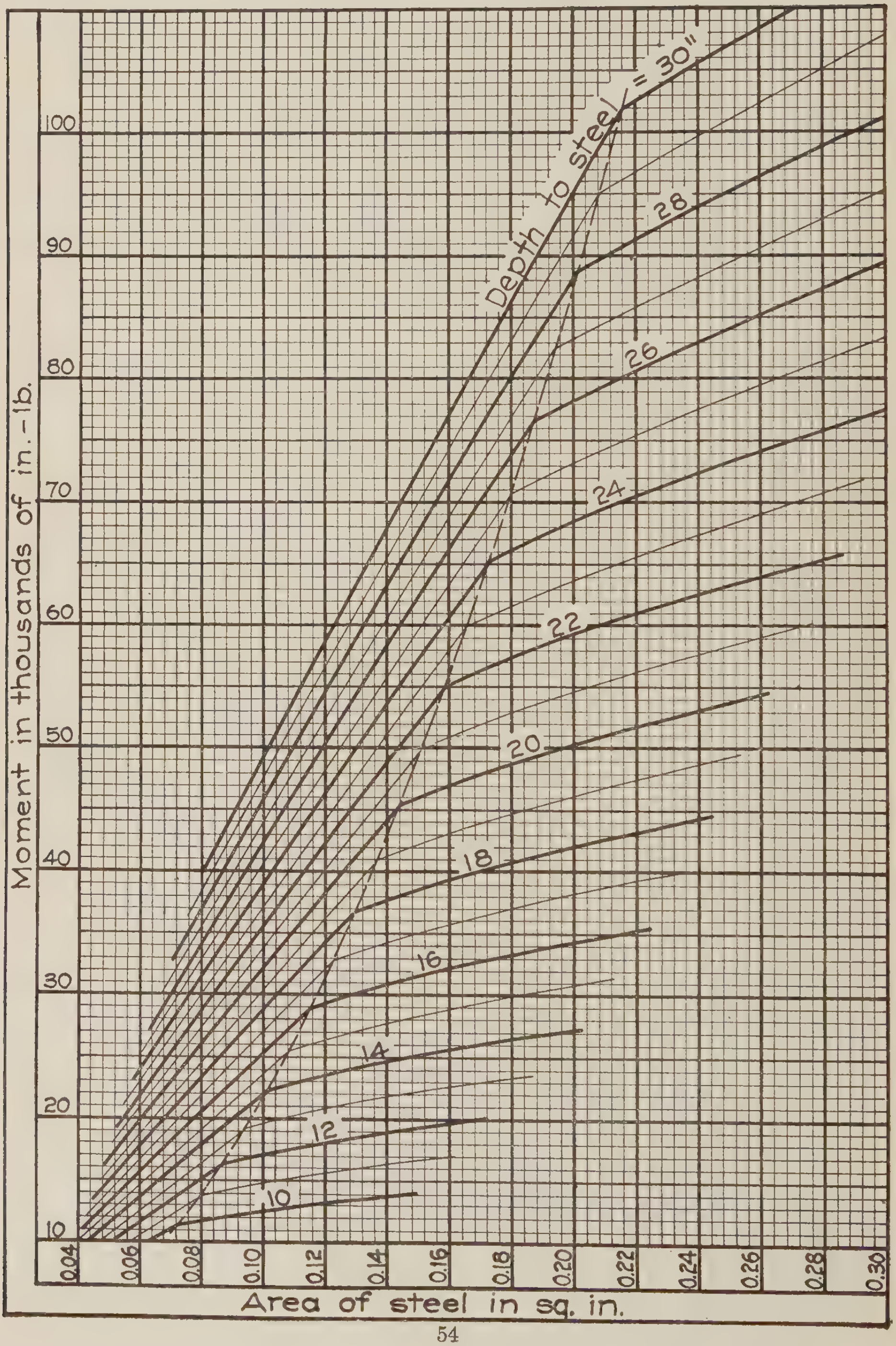
$f_c = 700$
$f_s = 16{,}000$
$n = 15$



RECTANGULAR
BEAMS

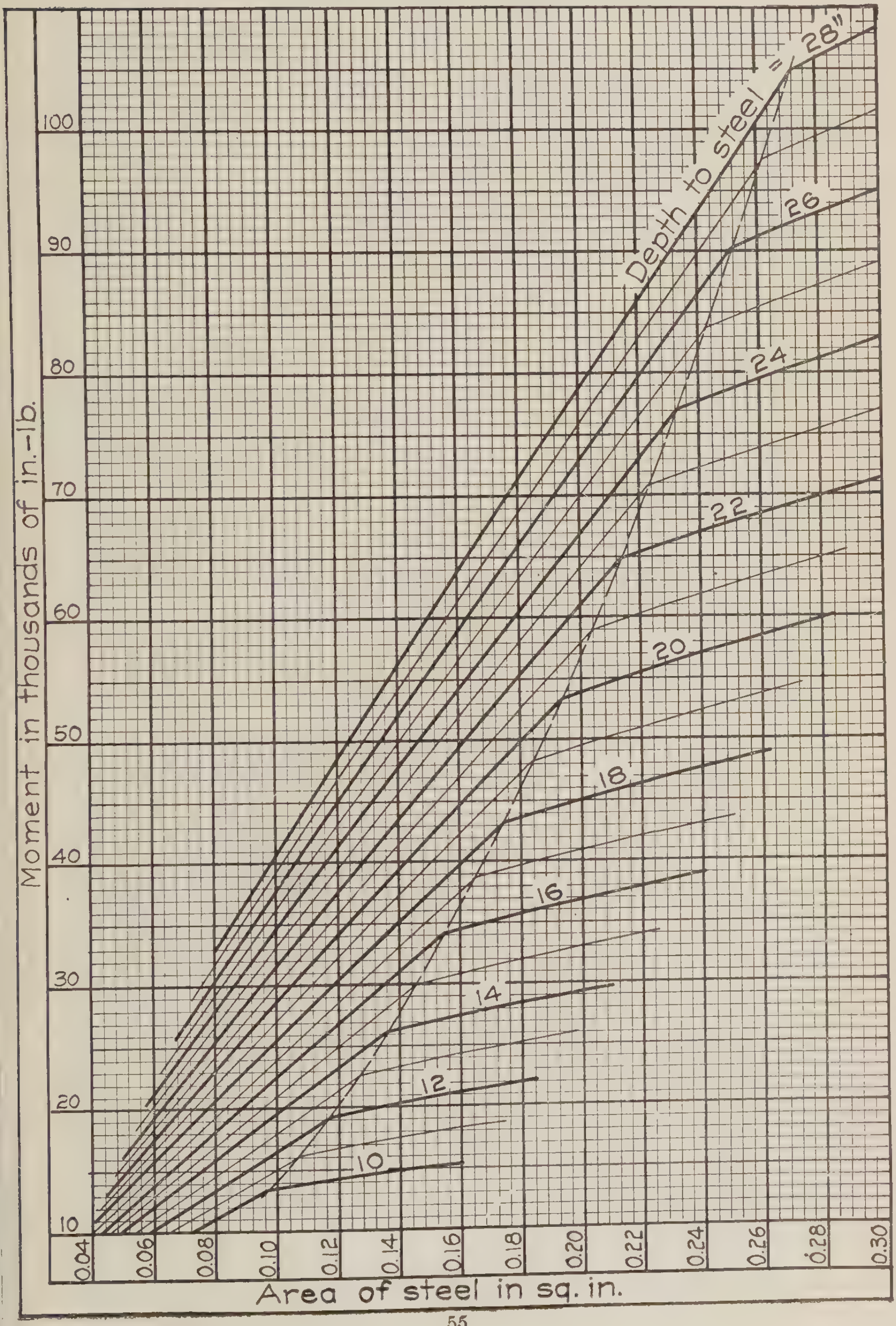
*$f_c = 700$*
*$f_s = 18{,}000$*
*$n = 15$*

## MOMENT OF RESISTANCE AND AREA OF STEEL FOR BEAMS ONE INCH WIDE



# MOMENT OF RESISTANCE AND AREA OF STEEL FOR BEAMS ONE INCH WIDE

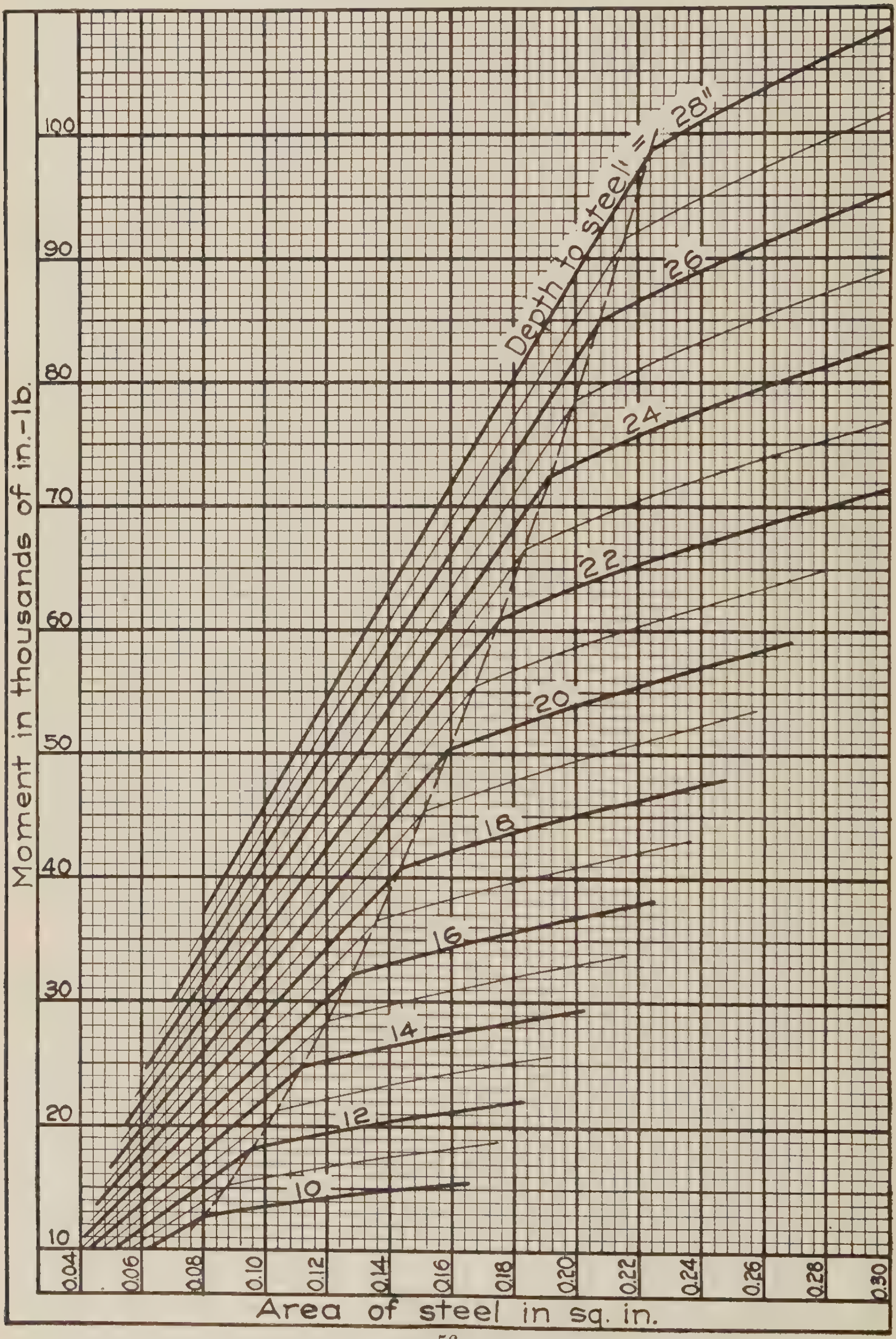
$f_c = 750$
$f_s = 16,000$
$n = 15$



**RECTANGULAR BEAMS**

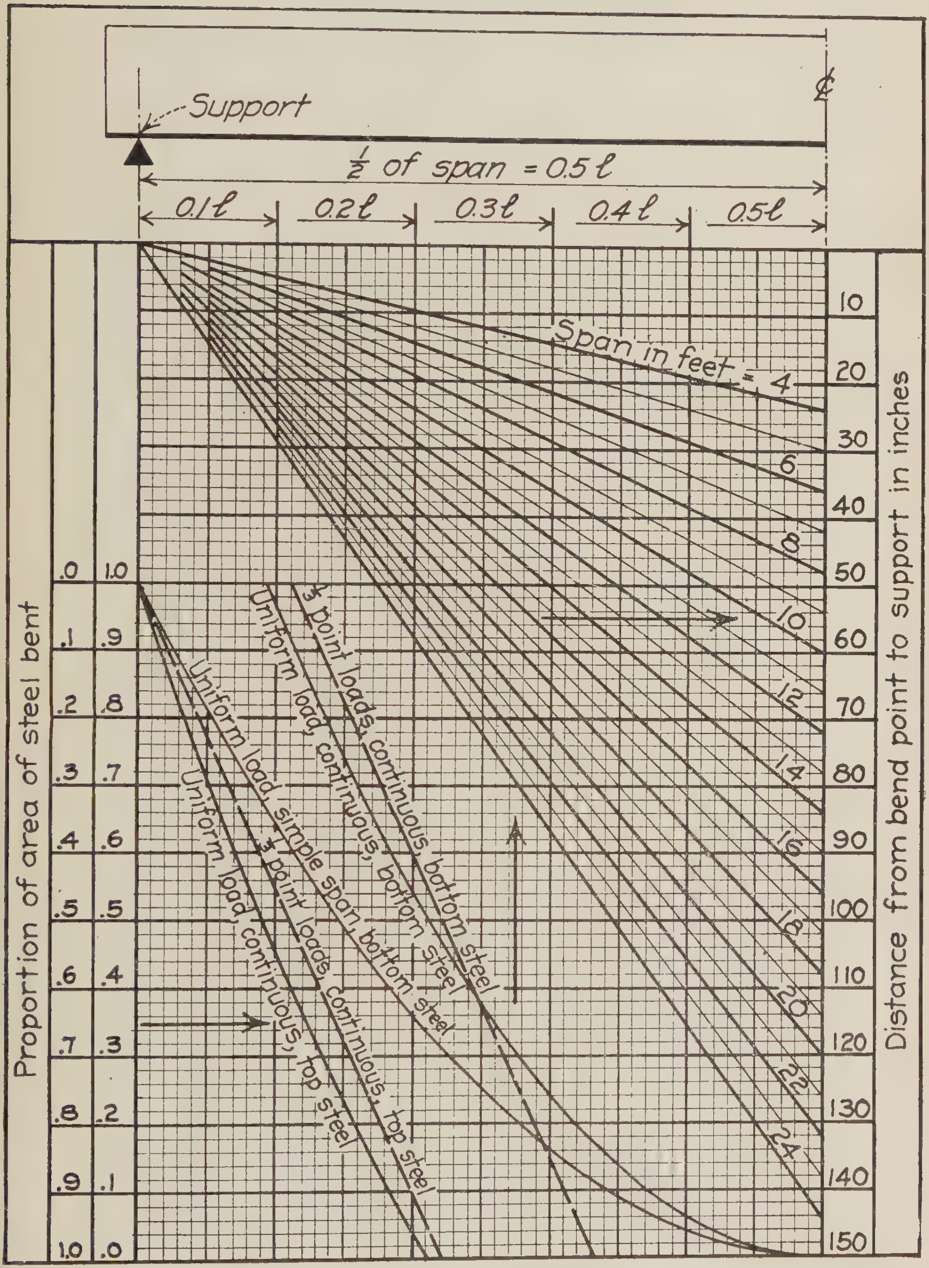
$f_c = 750$
$f_s = 18{,}000$
$n = 15$

### MOMENT OF RESISTANCE AND AREA OF STEEL FOR BEAMS ONE INCH WIDE



RECTANGULAR
BEAMS

## DIAGRAM FOR LOCATING POINTS TO BEND HORIZONTAL STEEL



RECTANGULAR
BEAMS

## AREAS AND PERIMETERS
## OF
## COMBINATIONS OF FOUR RODS

| Square rods | | Number and size | | | | | | | Round rods | |
|---|---|---|---|---|---|---|---|---|---|---|
| Area (sq. in.) | Perimeter (in.) | ½ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | Area (sq. in.) | Perimeter (in.) |
| 1.00 | 8.0 | 4 | .. | .. | .. | .. | .. | .. | 0.79 | 6.28 |
| 1.14 | 8.5 | 3 | 1 | .. | .. | .. | .. | .. | 0.89 | 6.68 |
| 1.28 | 9.0 | 2 | 2 | .. | .. | .. | .. | .. | 1.01 | 7.07 |
| 1.31 | 9.0 | 3 | .. | 1 | .. | .. | .. | .. | 1.03 | 7.07 |
| 1.42 | 9.5 | 1 | 3 | .. | .. | .. | .. | .. | 1.12 | 7.46 |
| 1.52 | 9.5 | 3 | .. | .. | 1 | .. | .. | .. | 1.19 | 7.46 |
| 1.56 | 10.0 | .. | 4 | .. | .. | .. | .. | .. | 1.23 | 7.85 |
| 1.63 | 10.0 | 2 | .. | 2 | .. | .. | .. | .. | 1.28 | 7.85 |
| 1.73 | 10.5 | .. | 3 | 1 | .. | .. | .. | .. | 1.36 | 8.25 |
| 1.91 | 11.0 | .. | 2 | 2 | .. | .. | .. | .. | 1.50 | 8.64 |
| 1.94 | 11.0 | .. | 3 | .. | 1 | .. | .. | .. | 1.52 | 8.64 |
| 1.94 | 11.0 | 1 | .. | 3 | .. | .. | .. | .. | 1.52 | 8.64 |
| 2.03 | 11.0 | 2 | .. | .. | 2 | .. | .. | .. | 1.60 | 8.64 |
| 2.08 | 11.5 | .. | 1 | 3 | .. | .. | .. | .. | 1.63 | 9.03 |
| 2.17 | 11.5 | .. | 3 | .. | .. | 1 | .. | .. | 1.71 | 9.03 |
| 2.25 | 12.0 | .. | .. | 4 | .. | .. | .. | .. | 1.77 | 9.43 |
| 2.31 | 12.0 | .. | 2 | .. | 2 | .. | .. | .. | 1.82 | 9.43 |
| 2.45 | 12.5 | .. | .. | 3 | 1 | .. | .. | .. | 1.93 | 9.82 |
| 2.55 | 12.5 | 1 | .. | .. | 3 | .. | .. | .. | 2.00 | 9.82 |
| 2.66 | 13.0 | .. | .. | 2 | 2 | .. | .. | .. | 2.09 | 10.21 |
| 2.69 | 13.0 | .. | 1 | .. | 3 | .. | .. | .. | 2.11 | 10.21 |
| 2.69 | 13.0 | .. | .. | 3 | .. | 1 | .. | .. | 2.11 | 10.21 |
| 2.78 | 13.0 | .. | 2 | .. | .. | 2 | .. | .. | 2.18 | 10.21 |
| 2.86 | 13.5 | .. | .. | 1 | 3 | .. | .. | .. | 2.24 | 10.60 |
| 2.95 | 13.5 | .. | .. | 3 | .. | .. | 1 | .. | 2.32 | 10.60 |
| 3.06 | 14.0 | .. | .. | .. | 4 | .. | .. | .. | 2.41 | 11.00 |
| 3.13 | 14.0 | .. | .. | 2 | .. | 2 | .. | .. | 2.45 | 11.00 |
| 3.30 | 14.5 | .. | .. | .. | 3 | 1 | .. | .. | 2.59 | 11.39 |
| 3.39 | 14.5 | .. | 1 | .. | .. | 3 | .. | .. | 2.66 | 11.39 |
| 3.53 | 15.0 | .. | .. | .. | 2 | 2 | .. | .. | 2.77 | 11.78 |
| 3.56 | 15.0 | .. | .. | 1 | .. | 3 | .. | .. | 2.80 | 11.78 |
| 3.56 | 15.0 | .. | .. | .. | 3 | .. | 1 | .. | 2.80 | 11.78 |
| 3.66 | 15.0 | .. | .. | 2 | .. | .. | 2 | .. | 2.87 | 11.78 |
| 3.77 | 15.5 | .. | .. | .. | 1 | 3 | .. | .. | 2.96 | 12.17 |
| 3.86 | 15.5 | .. | .. | .. | 3 | .. | .. | 1 | 3.03 | 12.17 |
| 4.00 | 16.0 | .. | .. | .. | .. | 4 | .. | .. | 3.14 | 12.56 |
| 4.06 | 16.0 | .. | .. | .. | 2 | .. | 2 | .. | 3.19 | 12.56 |
| 4.27 | 16.5 | .. | .. | .. | .. | 3 | 1 | .. | 3.35 | 12.96 |
| 4.36 | 16.5 | .. | .. | 1 | .. | .. | 3 | .. | 3.42 | 12.96 |
| 4.53 | 17.0 | .. | .. | .. | .. | 2 | 2 | .. | 3.56 | 13.35 |
| 4.56 | 17.0 | .. | .. | .. | .. | 3 | .. | 1 | 3.58 | 13.35 |
| 4.56 | 17.0 | .. | .. | .. | 1 | .. | 3 | .. | 3.58 | 13.35 |
| 4.66 | 17.0 | .. | .. | .. | 2 | .. | .. | 2 | 3.66 | 13.35 |
| 4.80 | 17.5 | .. | .. | .. | .. | 1 | 3 | .. | 3.77 | 13.74 |
| 5.06 | 18.0 | .. | .. | .. | .. | .. | 4 | .. | 3.98 | 14.14 |
| 5.13 | 18.0 | .. | .. | .. | .. | 2 | .. | 2 | 4.02 | 14.14 |
| 5.36 | 18.5 | .. | .. | .. | .. | .. | 3 | 1 | 4.21 | 14.53 |
| 5.45 | 18.5 | .. | .. | .. | 1 | .. | .. | 3 | 4.28 | 14.53 |
| 5.66 | 19.0 | .. | .. | .. | .. | .. | 2 | 2 | 4.44 | 14.92 |
| 5.69 | 19.0 | .. | .. | .. | .. | 1 | .. | 3 | 4.47 | 14.92 |
| 5.95 | 19.5 | .. | .. | .. | .. | .. | 1 | 3 | 4.67 | 15.32 |
| 6.25 | 20.0 | .. | .. | .. | .. | .. | .. | 4 | 4.91 | 15.71 |

# AREAS AND PERIMETERS OF COMBINATIONS OF SIX RODS

| Square rods | | Number and size | | | | | | Round rods | | Square rods | | Number and size | | | | | | Round rods | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (sq. in.) | Perimeter (in.) | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | Area (sq. in.) | Perimeter (in.) | Area (sq. in.) | Perimeter (in.) | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | Area (sq. in.) | Perimeter (in.) |
| 2.34 | 15.0 | 6 | .. | .. | .. | .. | .. | 1.84 | 11.78 | 5.39 | 22.5 | .. | .. | 5 | .. | .. | 1 | 4.23 | 17.67 |
| 2.52 | 15.5 | 5 | 1 | .. | .. | .. | .. | 1.98 | 12.17 | 5.48 | 22.5 | .. | 3 | .. | .. | 3 | .. | 4.31 | 17.67 |
| 2.69 | 16.0 | 4 | 2 | .. | .. | .. | .. | 2.11 | 12.57 | 5.53 | 23.0 | .. | .. | 2 | 4 | .. | .. | 4.34 | 18.07 |
| 2.72 | 16.0 | 5 | .. | 1 | .. | .. | .. | 2.14 | 12.57 | 5.56 | 23.0 | .. | 1 | .. | 5 | .. | .. | 4.37 | 18.07 |
| 2.86 | 16.5 | 3 | 3 | .. | .. | .. | .. | 2.25 | 12.96 | 5.59 | 23.0 | .. | .. | 4 | .. | 2 | .. | 4.39 | 18.07 |
| 2.95 | 16.5 | 5 | .. | .. | 1 | .. | .. | 2.32 | 12.96 | 5.77 | 23.5 | .. | .. | 1 | 5 | .. | .. | 4.53 | 18.46 |
| 3.03 | 17.0 | 2 | 4 | .. | .. | .. | .. | 2.38 | 13.35 | 6.00 | 24.0 | .. | .. | .. | 6 | .. | .. | 4.71 | 18.85 |
| 3.09 | 17.0 | 4 | .. | 2 | .. | .. | .. | 2.43 | 13.35 | 6.09 | 24.0 | .. | .. | 3 | .. | 3 | .. | 4.79 | 18.85 |
| 3.20 | 17.5 | 1 | 5 | .. | .. | .. | .. | 2.52 | 13.74 | 6.19 | 24.0 | .. | 2 | .. | .. | 4 | .. | 4.86 | 18.85 |
| 3.38 | 18.0 | .. | 6 | .. | .. | .. | .. | 2.65 | 14.14 | 6.19 | 24.0 | .. | .. | 4 | .. | .. | 2 | 4.86 | 18.85 |
| 3.47 | 18.0 | 3 | .. | 3 | .. | .. | .. | 2.72 | 14.14 | 6.27 | 24.5 | .. | .. | .. | 5 | 1 | .. | 4.92 | 19.24 |
| 3.56 | 18.0 | 4 | .. | .. | 2 | .. | .. | 2.80 | 14.14 | 6.53 | 25.0 | .. | .. | .. | 4 | 2 | .. | 5.13 | 19.64 |
| 3.58 | 18.5 | .. | 5 | 1 | .. | .. | .. | 2.81 | 14.53 | 6.56 | 25.0 | .. | .. | .. | 5 | .. | 1 | 5.15 | 19.64 |
| 3.78 | 19.0 | .. | 4 | 2 | .. | .. | .. | 2.97 | 14.92 | 6.59 | 25.0 | .. | .. | 2 | .. | 4 | .. | 5.18 | 19.64 |
| 3.81 | 19.0 | .. | 5 | .. | 1 | .. | .. | 2.99 | 14.92 | 6.80 | 25.5 | .. | .. | .. | 3 | 3 | .. | 5.34 | 20.03 |
| 3.84 | 19.0 | 2 | .. | 4 | .. | .. | .. | 3.02 | 14.92 | 6.89 | 25.5 | .. | 1 | .. | .. | 5 | .. | 5.41 | 20.03 |
| 3.98 | 19.5 | .. | 3 | 3 | .. | .. | .. | 3.13 | 15.32 | 6.98 | 25.5 | .. | .. | 3 | .. | .. | 3 | 5.48 | 20.03 |
| 4.08 | 19.5 | .. | 5 | .. | .. | 1 | .. | 3.20 | 15.32 | 7.06 | 26.0 | .. | .. | .. | 2 | 4 | .. | 5.55 | 20.42 |
| 4.17 | 19.5 | 3 | .. | .. | 3 | .. | .. | 3.28 | 15.32 | 7.09 | 26.0 | .. | .. | 1 | .. | 5 | .. | 5.57 | 20.42 |
| 4.19 | 20.0 | .. | 2 | 4 | .. | .. | .. | 3.29 | 15.71 | 7.13 | 26.0 | .. | .. | .. | 4 | .. | 2 | 5.60 | 20.42 |
| 4.22 | 20.0 | 1 | .. | 5 | .. | .. | .. | 3.31 | 15.71 | 7.33 | 26.5 | .. | .. | .. | 1 | 5 | .. | 5.76 | 20.81 |
| 4.25 | 20.0 | .. | 4 | .. | 2 | .. | .. | 3.34 | 15.71 | 7.59 | 27.0 | .. | .. | .. | .. | 6 | .. | 5.96 | 21.20 |
| 4.39 | 20.5 | .. | 1 | 5 | .. | .. | .. | 3.45 | 16.10 | 7.69 | 27.0 | .. | .. | .. | 3 | .. | 3 | 6.04 | 21.20 |
| 4.59 | 21.0 | .. | .. | 6 | .. | .. | .. | 3.61 | 16.49 | 7.78 | 27.0 | .. | .. | 2 | .. | .. | 4 | 6.11 | 21.20 |
| 4.69 | 21.0 | .. | 3 | .. | 3 | .. | .. | 3.68 | 16.49 | 7.89 | 27.5 | .. | .. | .. | .. | 5 | 1 | 6.19 | 21.60 |
| 4.78 | 21.0 | 2 | .. | .. | 4 | .. | .. | 3.76 | 16.49 | 8.19 | 28.0 | .. | .. | .. | .. | 4 | 2 | 6.43 | 21.99 |
| 4.78 | 21.0 | .. | 4 | .. | .. | 2 | .. | 3.76 | 16.49 | 8.25 | 28.0 | .. | .. | .. | 2 | .. | 4 | 6.48 | 21.99 |
| 4.83 | 21.5 | .. | .. | 5 | 1 | .. | .. | 3.79 | 16.89 | 8.48 | 28.5 | .. | .. | .. | .. | 3 | 3 | 6.66 | 22.38 |
| 5.06 | 22.0 | .. | .. | 4 | 2 | .. | .. | 3.98 | 17.28 | 8.58 | 28.5 | .. | .. | 1 | .. | .. | 5 | 6.74 | 22.38 |
| 5.09 | 22.0 | .. | .. | 5 | .. | 1 | .. | 4.00 | 17.28 | 8.78 | 29.0 | .. | .. | .. | .. | 2 | 4 | 6.90 | 22.78 |
| 5.13 | 22.0 | .. | 2 | .. | 4 | .. | .. | 4.03 | 17.28 | 8.81 | 29.0 | .. | .. | .. | 1 | .. | 5 | 6.92 | 22.78 |
| 5.30 | 22.5 | .. | .. | 3 | 3 | .. | .. | 4.16 | 17.67 | 9.08 | 29.5 | .. | .. | .. | .. | 1 | 5 | 7.13 | 23.17 |
| 5.39 | 22.5 | 1 | .. | .. | 5 | .. | .. | 4.23 | 17.67 | 9.38 | 30.0 | .. | .. | .. | .. | .. | 6 | 7.36 | 23.56 |

## AREAS AND PERIMETERS OF COMBINATIONS OF EIGHT RODS

| Square rods | | Number and size | | | | | Round rods | | Square rods | | Number and size | | | | | Round rods | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (sq. in.) | Perimeter (in.) | ¾ | ⅞ | 1 | 1⅛ | 1¼ | Area (sq. in.) | Perimeter (in.) | Area (sq. in.) | Perimeter (in.) | ¾ | ⅞ | 1 | 1⅛ | 1¼ | Area (sq. in.) | Perimeter (in.) |
| 4.50 | 24.0 | 8 | .. | .. | .. | .. | 3.53 | 18.85 | 8.12 | 32.0 | .. | 4 | .. | 4 | .. | 6.38 | 25.14 |
| 4.70 | 24.5 | 7 | 1 | .. | .. | .. | 3.69 | 19.24 | 8.27 | 32.5 | .. | .. | 7 | 1 | .. | 6.49 | 25.53 |
| 4.91 | 25.0 | 6 | 2 | .. | .. | .. | 3.85 | 19.64 | 8.52 | 32.5 | .. | 5 | .. | .. | 3 | 6.69 | 25.53 |
| 4.94 | 25.0 | 7 | .. | 1 | .. | .. | 3.88 | 19.64 | 8.53 | 33.0 | .. | .. | 6 | 2 | .. | 6.70 | 25.92 |
| 5.11 | 25.5 | 5 | 3 | .. | .. | .. | 4.01 | 20.03 | 8.56 | 33.0 | .. | .. | 7 | .. | 1 | 6.72 | 25.92 |
| 5.20 | 25.5 | 7 | .. | .. | 1 | .. | 4.09 | 20.03 | 8.62 | 33.0 | .. | 3 | .. | 5 | .. | 6.77 | 25.92 |
| 5.31 | 26.0 | 4 | 4 | .. | .. | .. | 4.17 | 20.40 | 8.72 | 33.0 | 2 | .. | .. | 6 | .. | 6.85 | 25.92 |
| 5.38 | 26.0 | 6 | .. | 2 | .. | .. | 4.22 | 20.40 | 8.80 | 33.5 | .. | .. | 5 | 3 | .. | 6.91 | 26.31 |
| 5.52 | 26.5 | 3 | 5 | .. | .. | .. | 4.33 | 20.81 | 9.06 | 34.0 | .. | ... | 4 | 4 | .. | 7.12 | 26.70 |
| 5.72 | 27.0 | 2 | 6 | .. | .. | .. | 4.49 | 21.20 | 9.12 | 34.0 | .. | 2 | .. | 6 | .. | 7.17 | 26.70 |
| 5.81 | 27.0 | 5 | .. | 3 | .. | .. | 4.57 | 21.20 | 9.13 | 34.0 | .. | .. | 6 | .. | 2 | 7.17 | 26.70 |
| 5.91 | 27.0 | 6 | .. | .. | 2 | .. | 4.64 | 21.20 | 9.31 | 34.0 | .. | 4 | .. | .. | 4 | 7.31 | 26.70 |
| 5.92 | 27.5 | 1 | 7 | .. | .. | .. | 4.65 | 21.60 | 9.33 | 34.5 | .. | .. | 3 | 5 | .. | 7.33 | 27.10 |
| 6.12 | 28.0 | .. | 8 | .. | .. | .. | 4.81 | 21.99 | 9.42 | 34.5 | 1 | .. | .. | 7 | .. | 7.40 | 27.10 |
| 6.25 | 28.0 | 4 | .. | 4 | .. | .. | 4.91 | 21.99 | 9.59 | 35.0 | .. | .. | 2 | 6 | .. | 7.53 | 27.49 |
| 6.36 | 28.5 | .. | 7 | 1 | .. | .. | 4.99 | 22.38 | 9.62 | 35.0 | .. | 1 | .. | 7 | .. | 7.56 | 27.49 |
| 6.59 | 29.0 | .. | 6 | 2 | .. | .. | 5.18 | 22.78 | 9.69 | 35.0 | .. | .. | 5 | .. | 3 | 7.61 | 27.49 |
| 6.61 | 28.5 | 5 | .. | .. | 3 | .. | 5.19 | 22.38 | 9.86 | 35.5 | .. | .. | 1 | 7 | .. | 7.74 | 27.88 |
| 6.62 | 29.0 | .. | 7 | .. | 1 | .. | 5.20 | 22.78 | 10.11 | 35.5 | .. | 3 | .. | .. | 5 | 7.94 | 27.88 |
| 6.69 | 29.0 | 3 | .. | 5 | .. | .. | 5.25 | 22.78 | 10.12 | 36.0 | .. | .. | .. | 8 | .. | 7.95 | 28.28 |
| 6.83 | 29.5 | .. | 5 | 3 | .. | .. | 5.36 | 23.17 | 10.25 | 36.0 | .. | .. | 4 | .. | 4 | 8.05 | 28.28 |
| 6 92 | 29.5 | .. | 7 | .. | .. | 1 | 5.44 | 23.17 | 10.42 | 36.5 | .. | .. | .. | 7 | 1 | 8.19 | 28.67 |
| 7.06 | 30.0 | .. | 4 | 4 | .. | .. | 5.55 | 23.56 | 10.72 | 37.0 | .. | .. | .. | 6 | 2 | 8.42 | 29.06 |
| 7.12 | 30.0 | .. | 6 | .. | 2 | .. | 5.60 | 23.56 | 10.81 | 37.0 | .. | .. | 3 | .. | 5 | 8.49 | 29.06 |
| 7.13 | 30.0 | 2 | .. | 6 | .. | .. | 5.60 | 23.56 | 10.91 | 37.0 | .. | 2 | .. | .. | 6 | 8.56 | 29.06 |
| 7.30 | 30.5 | .. | 3 | 5 | .. | .. | 5.73 | 23.96 | 11.02 | 37.5 | .. | .. | .. | 5 | 3 | 8.65 | 29.45 |
| 7.31 | 30.0 | 4 | .. | .. | 4 | .. | 5.74 | 23.56 | 11.31 | 38.0 | .. | .. | .. | 4 | 4 | 8.88 | 29.85 |
| 7.53 | 31.0 | .. | 2 | 6 | .. | .. | 5.91 | 24.35 | 11.38 | 38.0 | .. | .. | 2 | .. | 6 | 8.93 | 29.85 |
| 7.56 | 31.0 | 1 | .. | 7 | .. | .. | 5.94 | 24.35 | 11.61 | 38.5 | .. | .. | .. | 3 | 5 | 9.12 | 30.24 |
| 7.63 | 31.0 | .. | 5 | .. | 3 | .. | 5.99 | 24.35 | 11.70 | 38.5 | .. | 1 | .. | .. | 7 | 9.19 | 30.24 |
| 7.72 | 31.0 | .. | 6 | .. | .. | 2 | 6.06 | 24.35 | 11.91 | 39.0 | .. | .. | .. | 2 | 6 | 9.35 | 30.63 |
| 7.77 | 31.5 | .. | 1 | 7 | .. | .. | 6.10 | 24.74 | 11.94 | 39.0 | .. | .. | 1 | .. | 7 | 9.37 | 30.63 |
| 8.00 | 32.0 | .. | .. | 8 | .. | .. | 6.28 | 25.14 | 12.20 | 39.5 | .. | .. | .. | 1 | 7 | 9.58 | 31.02 |
| 8.02 | 31.5 | 3 | .. | .. | 5 | .. | 6.30 | 24.74 | 12.50 | 40.0 | .. | .. | .. | .. | 8 | 9.82 | 31.42 |

TABLE 18

# AREAS AND PERIMETERS OF GROUPS OF RODS OF UNIFORM SIZE

| | Number | Size of rods | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ¼ | ⅜ | ½ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | 1⅜ | 1½ |
| Square rods | 1 | 0.0625<br>**1.0** | 0.1406<br>**1.5** | 0.2500<br>**2.0** | 0.3906<br>**2.5** | 0.5625<br>**3.0** | 0.7656<br>**3.5** | 1.000<br>**4.0** | 1.266<br>**4.5** | 1.563<br>**5.0** | 1.891<br>**5.5** | 2.250<br>**6.0** |
| | 2 | 0.1250<br>**2.0** | 0.2812<br>**3.0** | 0.5000<br>**4.0** | 0.7812<br>**5.0** | 1.125<br>**6.0** | 1.531<br>**7.0** | 2.000<br>**8.0** | 2.531<br>**9.0** | 3.125<br>**10.0** | 3.781<br>**11.0** | 4.500<br>**12.0** |
| | 3 | 0.1875<br>**3.0** | 0.4218<br>**4.5** | 0.7500<br>**6.0** | 1.172<br>**7.5** | 1.688<br>**9.0** | 2.297<br>**10.5** | 3.000<br>**12.0** | 3.797<br>**13.5** | 4.688<br>**15.0** | 5.672<br>**16.5** | 6.750<br>**18.0** |
| | 4 | 0.2500<br>**4.0** | 0.5624<br>**6.0** | 1.000<br>**8.0** | 1.563<br>**10.0** | 2.250<br>**12.0** | 3.062<br>**14.0** | 4.000<br>**16.0** | 5.062<br>**18.0** | 6.250<br>**20.0** | 7.562<br>**22.0** | 9.000<br>**24.0** |
| | 5 | 0.3125<br>**5.0** | 0.7030<br>**7.5** | 1.250<br>**10.0** | 1.953<br>**12.5** | 2.813<br>**15.0** | 3.828<br>**17.5** | 5.000<br>**20.0** | 6.328<br>**22.5** | 7.813<br>**25.0** | 9.453<br>**27.5** | 11.25<br>**30.0** |
| | 6 | 0.3750<br>**6.0** | 0.8436<br>**9.0** | 1.500<br>**12.0** | 2.344<br>**16.0** | 3.375<br>**18.0** | 4.594<br>**21.0** | 6.000<br>**24.0** | 7.594<br>**27.0** | 9.375<br>**30.0** | 11.34<br>**33.0** | 13.50<br>**36.0** |
| | 7 | 0.4375<br>**7.0** | 0.9842<br>**10.5** | 1.750<br>**14.0** | 2.734<br>**17.5** | 3.938<br>**21.0** | 5.359<br>**24.5** | 7.000<br>**28.0** | 8.859<br>**31.5** | 10.94<br>**35.0** | 13.23<br>**38.5** | 15.75<br>**42.0** |
| | 8 | 0.5000<br>**8.0** | 1.125<br>**12.0** | 2.000<br>**16.0** | 3.125<br>**20.0** | 4.500<br>**24.0** | 6.125<br>**28.0** | 8.000<br>**32.0** | 10.12<br>**36.0** | 12.50<br>**40.0** | 15.12<br>**44.0** | 18.00<br>**48.0** |
| | 9 | 0.5625<br>**9.0** | 1.265<br>**13.5** | 2.250<br>**18.0** | 3.516<br>**22.5** | 5.063<br>**27.0** | 6.890<br>**31.5** | 9.000<br>**36.0** | 11.39<br>**40.5** | 14.06<br>**45.0** | 17.02<br>**49.5** | 20.25<br>**54.0** |
| | 10 | 0.6250<br>**10.0** | 1.406<br>**15.0** | 2.500<br>**20.0** | 3.906<br>**25.0** | 5.625<br>**30.0** | 7.656<br>**35.0** | 10.00<br>**40.0** | 12.66<br>**45.0** | 15.63<br>**50.0** | 18.91<br>**55.0** | 22.50<br>**60.0** |
| Round rods | 1 | 0.0491<br>**0.785** | 0.1105<br>**1.18** | 0.1964<br>**1.571** | 0.3068<br>**1.96** | 0.4418<br>**2.35** | 0.6013<br>**2.75** | 0.7854<br>**3.14** | 0.9940<br>**3.53** | 1.227<br>**3.93** | 1.485<br>**4.32** | 1.767<br>**4.71** |
| | 2 | 0.0982<br>**1.57** | 0.2209<br>**2.36** | 0.3927<br>**3.14** | 0.6136<br>**3.93** | 0.8836<br>**4.71** | 1.203<br>**5.50** | 1.571<br>**6.28** | 1.988<br>**7.07** | 2.454<br>**7.85** | 2.970<br>**8.64** | 3.534<br>**9.42** |
| | 3 | 0.1473<br>**2.36** | 0.3313<br>**3.53** | 0.5890<br>**4.71** | 0.9204<br>**5.89** | 1.325<br>**7.07** | 1.804<br>**8.25** | 2.356<br>**9.43** | 2.982<br>**10.6** | 3.681<br>**11.8** | 4.455<br>**13.0** | 5.301<br>**14.1** |
| | 4 | 0.1964<br>**3.14** | 0.4418<br>**4.71** | 0.7854<br>**6.28** | 1.227<br>**7.85** | 1.767<br>**9.42** | 2.405<br>**11.0** | 3.142<br>**12.6** | 3.976<br>**14.1** | 4.908<br>**15.7** | 5.940<br>**17.3** | 7.068<br>**18.8** |
| | 5 | 0.2455<br>**3.93** | 0.5522<br>**5.89** | 0.9817<br>**7.85** | 1.534<br>**9.82** | 2.209<br>**11.8** | 3.006<br>**13.7** | 3.927<br>**15.7** | 4.970<br>**17.7** | 6.135<br>**19.6** | 7.425<br>**21.6** | 8.835<br>**23.6** |
| | 6 | 0.2946<br>**4.71** | 0.6627<br>**7.07** | 1.178<br>**9.43** | 1.841<br>**11.8** | 2.651<br>**14.1** | 3.608<br>**16.5** | 4.712<br>**18.9** | 5.964<br>**21.2** | 7.362<br>**23.6** | 8.910<br>**25.9** | 10.60<br>**28.3** |
| | 7 | 0.3437<br>**5.50** | 0.7731<br>**8.25** | 1.374<br>**11.0** | 2.148<br>**13.7** | 3.093<br>**16.5** | 4.209<br>**19.2** | 5.498<br>**22.0** | 6.958<br>**24.7** | 8.589<br>**27.5** | 10.39<br>**30.2** | 12.37<br>**33.0** |
| | 8 | 0.3928<br>**6.28** | 0.8836<br>**9.42** | 1.571<br>**12.6** | 2.454<br>**15.7** | 3.534<br>**18.8** | 4.810<br>**22.0** | 6.283<br>**25.1** | 7.952<br>**28.3** | 9.816<br>**31.4** | 11.88<br>**34.6** | 14.14<br>**37.7** |
| | 9 | 0.4419<br>**7.07** | 0.9940<br>**10.6** | 1.767<br>**14.1** | 2.761<br>**17.7** | 3.976<br>**21.2** | 5.412<br>**24.7** | 7.069<br>**28.3** | 8.946<br>**31.8** | 11.04<br>**35.3** | 13.37<br>**38.9** | 15.90<br>**42.4** |
| | 10 | 0.4910<br>**7.85** | 1.105<br>**11.8** | 1.964<br>**15.7** | 3.068<br>**19.6** | 4.418<br>**23.6** | 6.013<br>**27.5** | 7.854<br>**31.4** | 9.940<br>**35.3** | 12.27<br>**39.3** | 14.85<br>**43.2** | 17.67<br>**47.1** |

TABLE 19

## AREAS, PERIMETERS AND WEIGHTS OF RODS

| Size (inches) | Round rods | | | Square rods | | |
|---|---|---|---|---|---|---|
| | Area (square inches) | Perimeter (inches) | Weight per foot (pounds) | Area (square inches) | Perimeter (inches) | Weight per foot (pounds) |
| ¼ | 0.0491 | 0.785 | 0.167 | 0.0625 | 1.00 | 0.212 |
| 5/16 | 0.0767 | 0.982 | 0.261 | 0.0977 | 1.25 | 0.333 |
| ⅜ | 0.1104 | 1.178 | 0.375 | 0.1406 | 1.50 | 0.478 |
| 7/16 | 0.1503 | 1.374 | 0.511 | 0.1914 | 1.75 | 0.651 |
| ½ | 0.1963 | 1.571 | 0.667 | 0.2500 | 2.00 | 0.850 |
| 9/16 | 0.2485 | 1.767 | 0.845 | 0.3164 | 2.25 | 1.076 |
| ⅝ | 0.3068 | 1.964 | 1.043 | 0.3906 | 2.50 | 1.328 |
| 11/16 | 0.3712 | 2.160 | 1.262 | 0.4727 | 2.75 | 1.608 |
| ¾ | 0.4418 | 2.356 | 1.502 | 0.5625 | 3.00 | 1.913 |
| 13/16 | 0.5185 | 2.553 | 1.763 | 0.6602 | 3.25 | 2.245 |
| ⅞ | 0.6013 | 2.749 | 2.044 | 0.7656 | 3.50 | 2.603 |
| 15/16 | 0.6903 | 2.945 | 2.347 | 0.8789 | 3.75 | 2.989 |
| 1 | 0.7854 | 3.142 | 2.670 | 1.0000 | 4.00 | 3.400 |
| 1⅛ | 0.9940 | 3.534 | 3.379 | 1.2656 | 4.50 | 4.303 |
| 1¼ | 1.2272 | 3.927 | 4.173 | 1.5625 | 5.00 | 5.312 |
| 1⅜ | 1.4849 | 4.320 | 5.049 | 1.8906 | 5.50 | 6.428 |
| 1½ | 1.7671 | 4.712 | 6.008 | 2.2500 | 6.00 | 7.650 |
| 1⅝ | 2.0739 | 5.105 | 7.051 | 2.6406 | 6.50 | 8.978 |
| 1¾ | 2.4053 | 5.498 | 8.178 | 3.0625 | 7.00 | 10.41 |
| 1⅞ | 2.7612 | 5.891 | 9.388 | 3.5156 | 7.50 | 11.95 |
| 2 | 3.1416 | 6.283 | 10.68 | 4.0000 | 8.00 | 13.60 |
| 2¼ | 3.9761 | 7.069 | 13.52 | 5.0625 | 9.00 | 17.22 |
| 2½ | 4.9087 | 7.854 | 16.69 | 6.2500 | 10.00 | 21.25 |
| 2¾ | 5.9396 | 8.639 | 20.20 | 7.5625 | 11.00 | 25.71 |
| 3 | 7.0686 | 9.425 | 24.03 | 9.0000 | 12.00 | 30.60 |

# SECTION 4

## DOUBLY REINFORCED BEAMS

Diagrams 26 to 30 inclusive are particularly useful in checking the supports of continuous T-beams when the value of $\frac{d'}{d}$ is approximately $\frac{1}{10}$. The results are on the safe side when $\frac{d'}{d}$ is less than $\frac{1}{10}$. For different values of $\frac{M}{bd^2}$ they give directly the amounts of compressive and tensile steel required.

When the value of $\frac{d'}{d}$ does not approximate $\frac{1}{10}$, the formulas given below may be used. These are based on the fundamental fact that for any given values of $f_c$ and $f_s$, $k$ has exactly the same value regardless of the shape or type of beam. It follows from this that if steel is added to the section without changing the extreme fiber stresses, this added tensile and compressive steel must form a balanced couple whose stresses conform to the stresses already in the section.

Let $p_1$ = steel ratio for the beam without compressive steel.
$p_2$ = steel ratio for the added tensile steel.
$p = p_1 + p_2$.
$p'$ = steel ratio for compressive steel.
$M_1$ = moment of the beam without compressive steel.
$M_2$ = moment of the added steel couple.
$M = M_1 + M_2$

Then

$$k = \frac{1}{1 + \frac{f_s}{nf_c}}$$

$$p_1 = \frac{f_c k}{2f_s}$$

$$M_1 = f_s p_1 \left(1 - \frac{k}{3}\right) bd^2$$

$$M_2 = M - M_1$$

$$p_2 = \frac{M_2}{f_s\left(1 - \frac{d'}{d}\right) bd^2}$$

$$p = p_1 + p_2$$

$$p' = p_2 \frac{1 - k}{k - \frac{d'}{d}}$$

Diagram 31 is of general use. By means of this diagram and Table 20 it is possible to readily determine the stresses in the concrete and steel of a doubly reinforced rectangular beam for a given bending moment.

Diagram 32 is used to determine the length of embedment necessary to develop the actual compressive stress in the rods in the bottom of a continuous T-beam at the supports. The upper part of the diagram is general, and may be used to find length of embedment to provide for bond when the stress is the steel is either tension or compression.

### Finding Percentages of Tensile and Compressive Steel

*What percentages of tensile and compressive steel will be required when* $\frac{M}{bd^2} = 200$, *if* $f_c$ *is not to exceed* 750 *and* $f_s$ *is not to exceed* 18,000? $\frac{d'}{d} = 0.10$. $n = 15$.

From Diagram 28 we find that for $f_c = 750$, $f_s = 18{,}000$, and $\frac{M}{bd^2} = 200$

$$p = 0.0127 \text{ and } p' = 0.010$$

If $p$ should be increased to 0.0143, $f_s$ will be lowered to 16,000 and $p'$ to 0.0086.

*Given:* $b = 12$ *in.*, $d = 18$ *in.*, $\frac{d'}{d} = 0.15$, $M = 750{,}000$ *in.-lb.*, $f_c = 750$ and $f_s = 16{,}000$, $n = 15$. *Determine the required percentages of tensile aud compressive steel.*

From Table 14,

$$k = 0.413 \quad p_1 = 0.0097, \text{ and } K = 133.5$$

$$M_1 = (133.5)(12)(18)^2 = 519{,}000 \text{ in.-lb.}$$

$$M_2 = 750{,}000 - 519{,}000 = 231{,}000 \text{ in.-lb.}$$

$$p_2 = \frac{231{,}000}{(16{,}000)(0.85)(12)(18)^2} = 0.0044$$

$$p = p_1 + p_2 = 0.0141$$

$$p' = (0.0044)\left(\frac{1 - 0.413}{0.413 - 0.15}\right) = 0.0097$$

### Finding Length of Embedment of Compressive Steel

*Given a continuous beam reinforced with* 1-*in. rods (either square or round) in compression so that* $f_c = 750$; $f_s = 16{,}000$; $\frac{d'}{d} = 0.10$; $n = 15$; $u = 80$. *Find required length of embedment of compressive steel.*

From the lower part of Diagram 32, the compressive stress $f_s'$ is found to be 8540 lb. per sq. in. The upper diagram shows the length of embedment for 1-in. plain rods, with $u = 80$, to be 26½ in.

### Finding Stresses in Concrete and Steel

*A continuous T-beam, uniformly loaded, has a bending moment at the center of each span of* 356,300 *in.-lb. Negative bending moment at the supports and the positive bending moment at the center of span are figured by the formula,* $M = \frac{wl^2}{12}$. *The tensile steel at the center of span consists of four* ¾-*in. round bars.* $b' = 10$ *in.* $d = 15$ *in. Design the supports.*

At the supports the flange of the T-beam, being in tension, is negligible and the T-beam changes into a rectangular beam with steel in top and bottom. Two of the tension bars on each side of the supports will be bent up and made to lap over the top of the supports, while the other two bars on each side will be continued straight and lapped over supports at the bottom of beam.

The ratios of steel in tension and compression are the same, and are respectively:

$$p = p' = \frac{1.77}{(10)(15)} = 0.0118$$

(1.77 in above equation taken from Table 18.)

$$\frac{d'}{d} = \frac{2}{15} = 0.133$$

From Diagram 31, knowing $p' = p$, we obtain

$$\text{For } \frac{d'}{d} = 0.10 \ldots \begin{cases} k = 0.361 \\ j = 0.888 \end{cases}$$

$$\text{For } \frac{d'}{d} = 0.15 \ldots \begin{cases} k = 0.377 \\ j = 0.866 \end{cases}$$

Thus,

$$\text{For } \frac{d'}{d} = 0.133 \ldots \begin{cases} k = 0.372 \\ j = 0.873 \end{cases}$$

(It is usually well within the precision of the actual work, and on the safe side, to use the curves for the value of $\frac{d'}{d}$ next larger than the actual value. Thus in this problem the values of $k$ and $j$ for $\frac{d'}{d} = 0.15$ could be used with sufficient accuracy.)

Then

$$f_s = \frac{M}{A_s jd} = \frac{356{,}300}{(1.77)(0.873)(15)} = 15{,}400 \text{ lb. per sq. in.}$$

and, using Table 20,

$$f_c = \frac{k}{n(1-k)} \cdot f_s = (0.0394)(15{,}400) = 607 \text{ lb. per sq. in.}$$

The stresses in the concrete and steel are within the allowable and no haunch or additional steel is necessary.

The moment of resistance at the supports may be found as follows:

$$f_s = \frac{f_c n(1-k)}{k} = \frac{650}{0.0394} = 16{,}500 \text{ lb. per sq. in.}$$

Thus the moment of resistance depends on the steel and

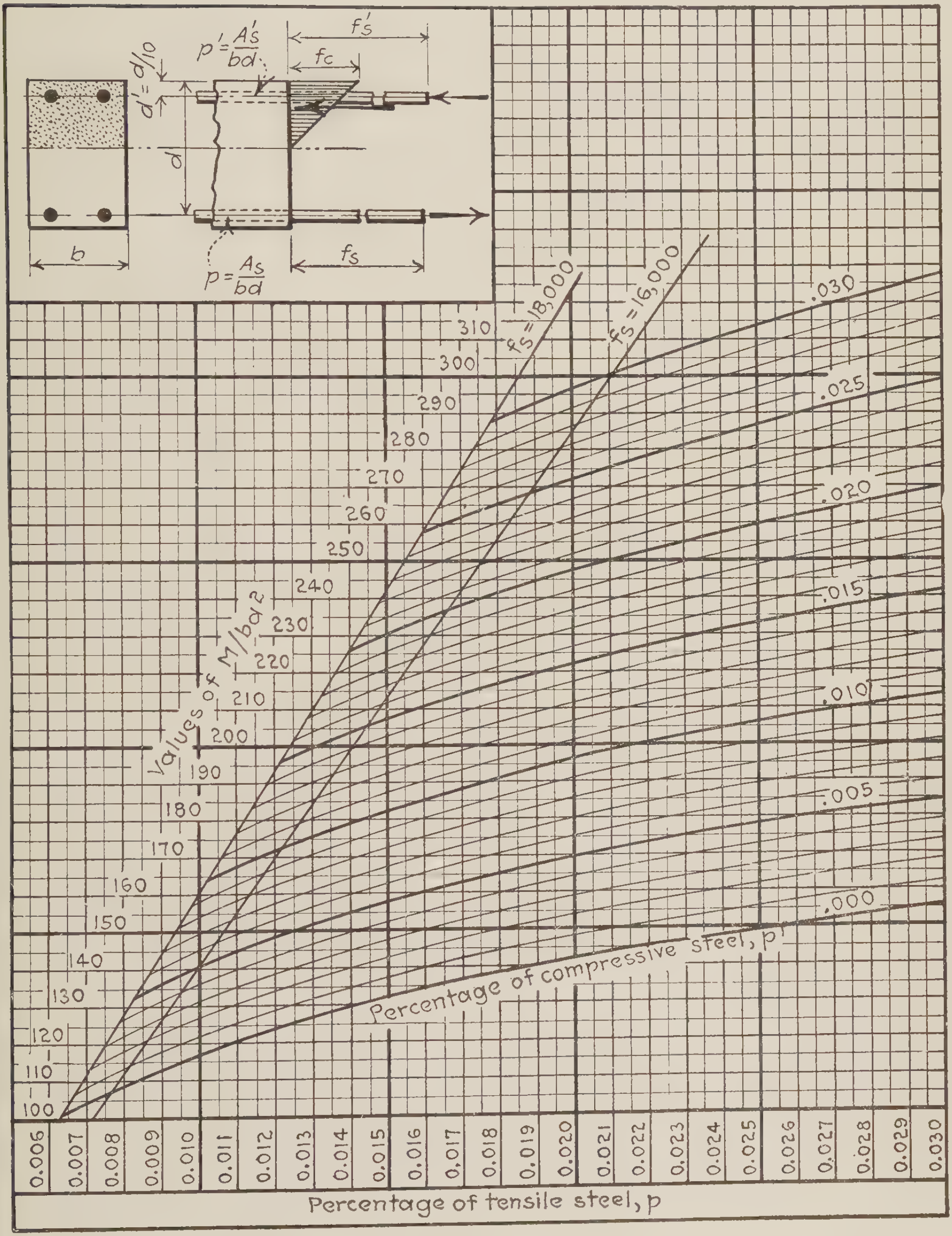
$$M_s = bd^2 f_s pj = (10)\ (15)^2\ (16{,}000)\ (0.0118)\ (0.873) = 371{,}000 \text{ in.-lb.}$$

## DOUBLY REINFORCED RECTANGULAR BEAMS

### VALUES OF $\frac{M}{bd^2}$, $p$, AND $p'$

$\frac{d'}{d} = \frac{1}{10}$

$f_c = 650$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$

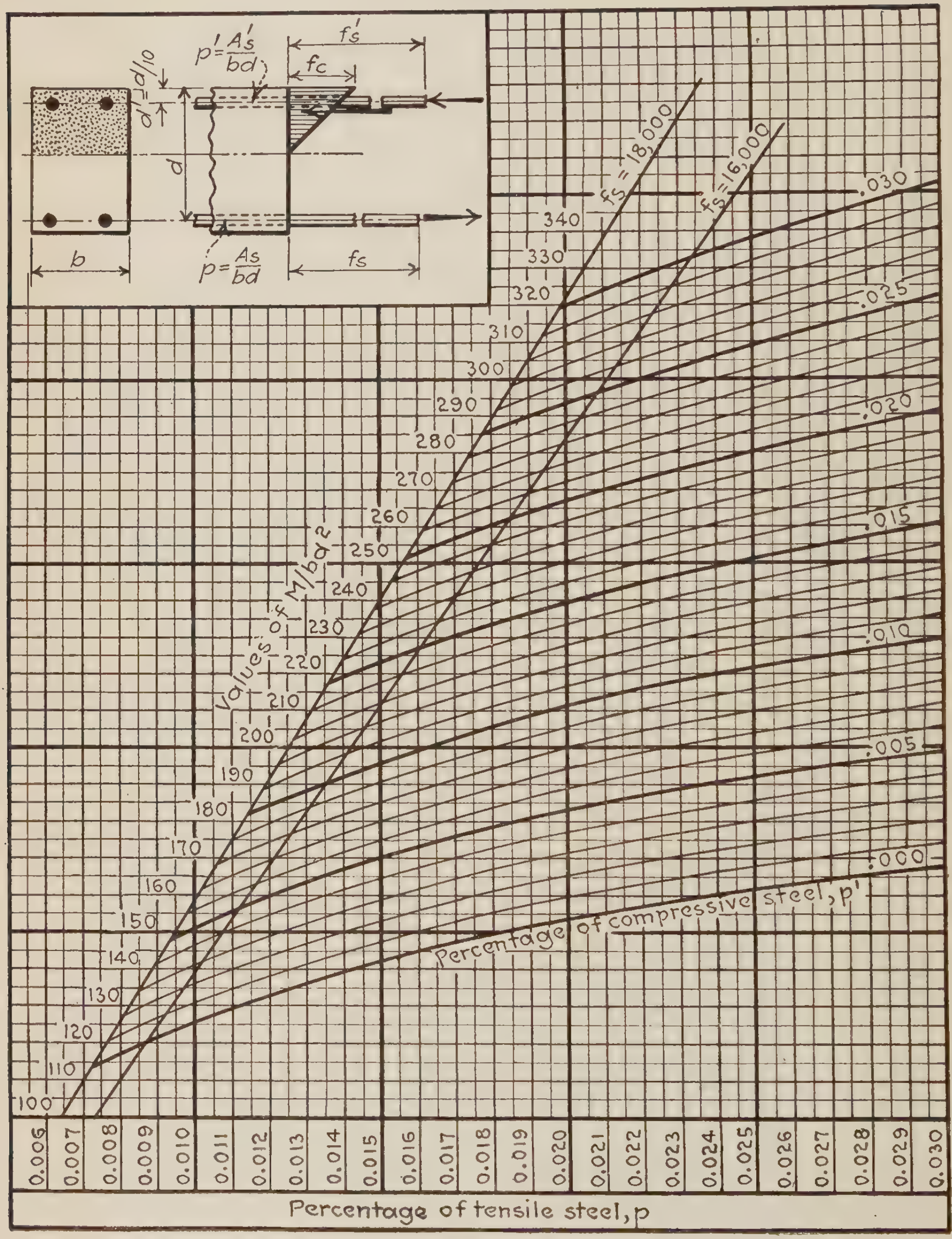


## DOUBLY REINFORCED RECTANGULAR BEAMS

### VALUES OF $\frac{M}{bd^2}$, p, AND p'

$\frac{d'}{d} = \frac{1}{10}$

$f_c = 700$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$

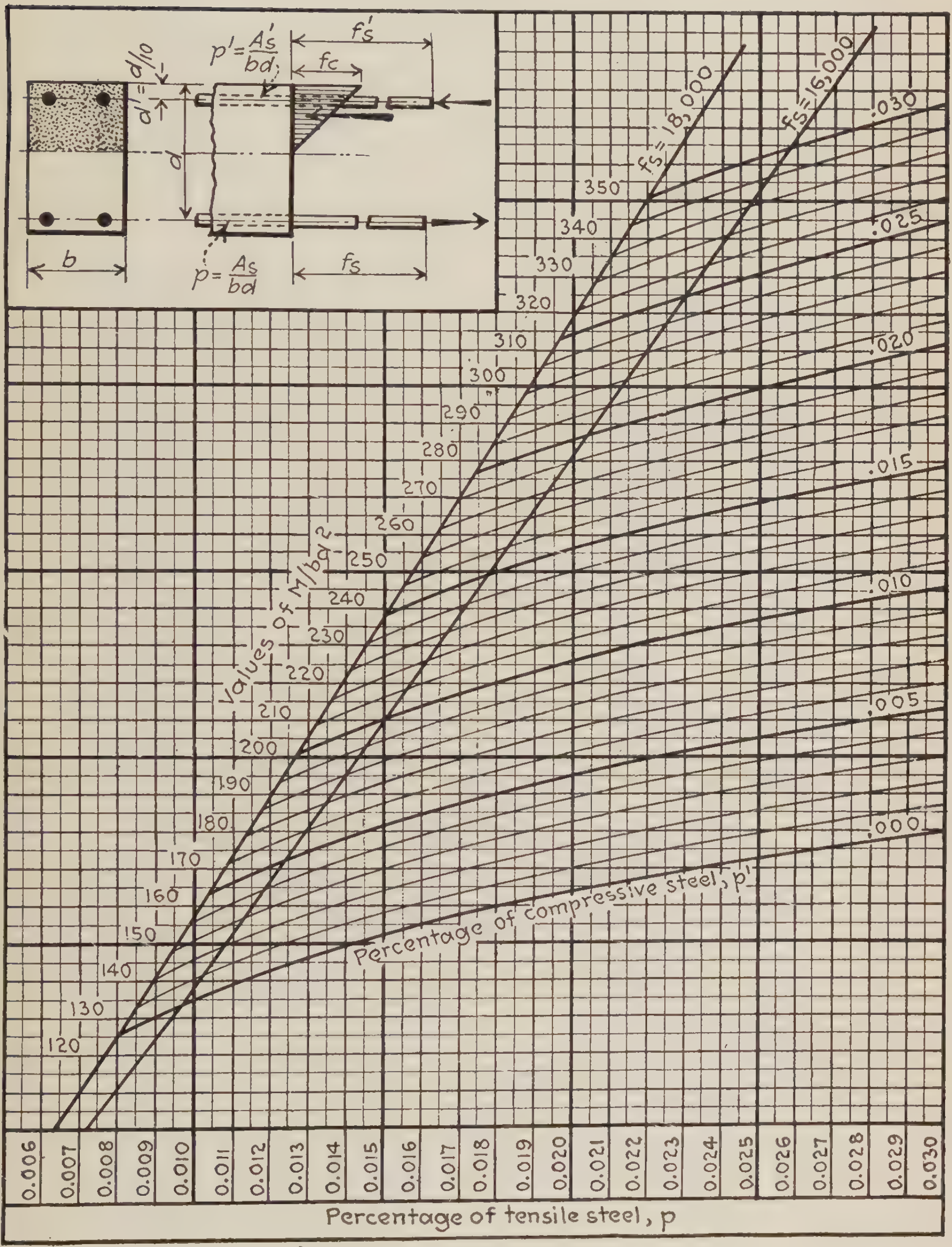


## DOUBLY REINFORCED RECTANGULAR BEAMS

### *VALUES OF $\frac{M}{bd^2}$, p, AND p'*

$$\frac{d'}{d} = \frac{1}{10}$$

$f_c = 750$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$

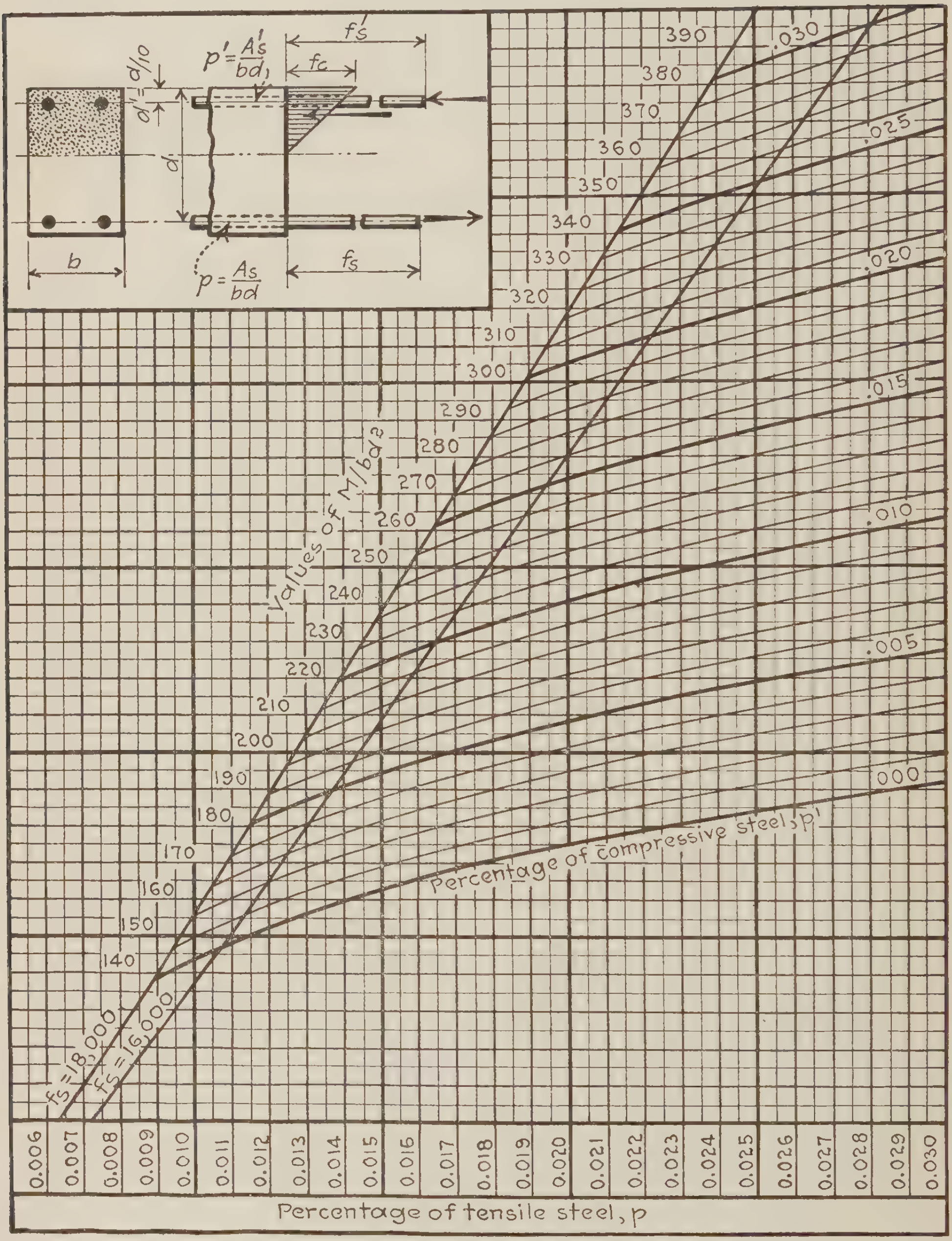


## DOUBLY REINFORCED RECTANGULAR BEAMS

### VALUES OF $\frac{M}{bd^2}$, $p$, AND $p'$

$\frac{d'}{d} = \frac{1}{10}$

$f_c = 800$
$f_s = 16,000$
$f_s = 18,000$
$n = 15$

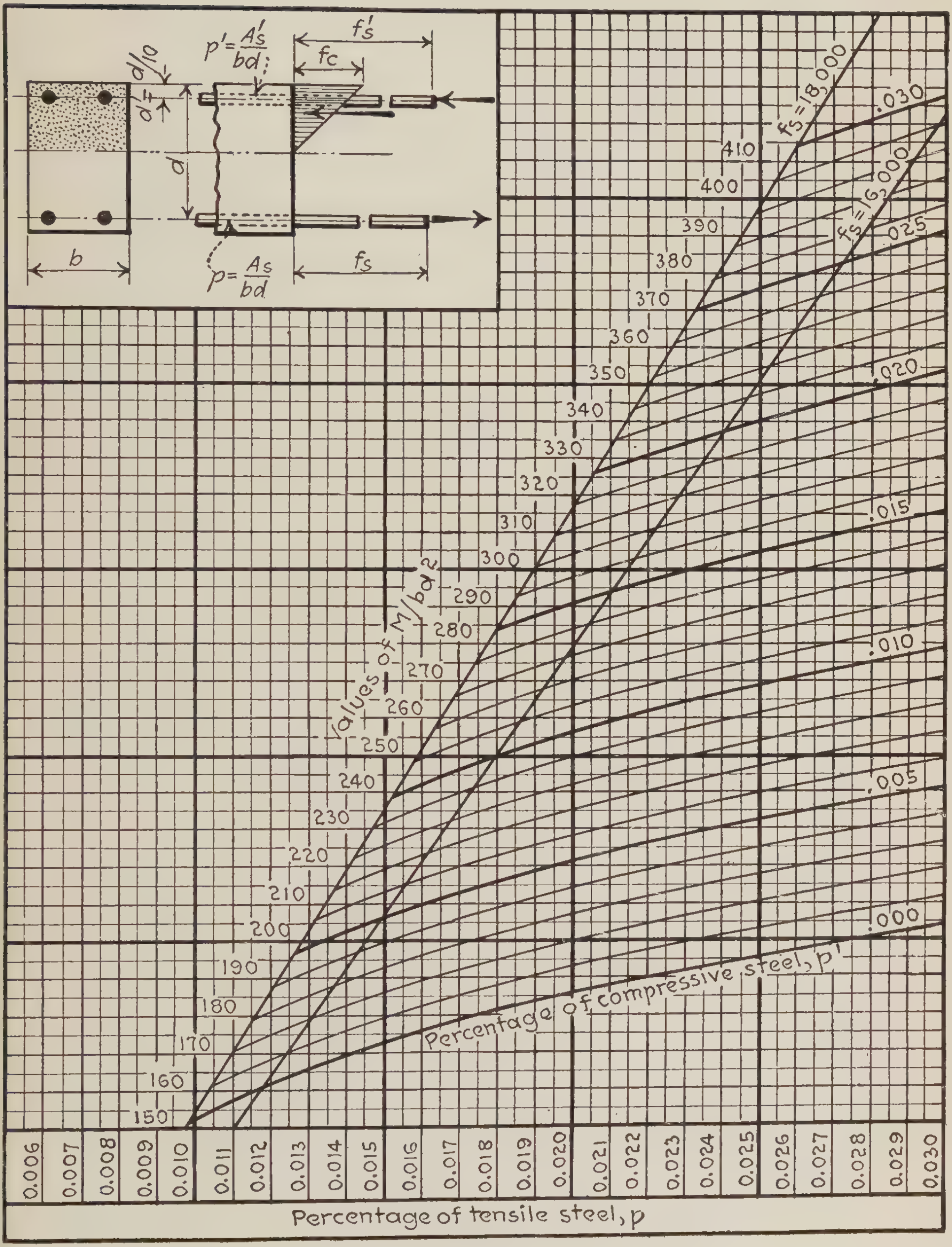


## DOUBLY REINFORCED RECTANGULAR BEAMS

### VALUES OF $\frac{M}{bd^2}$, $p$, AND $p'$

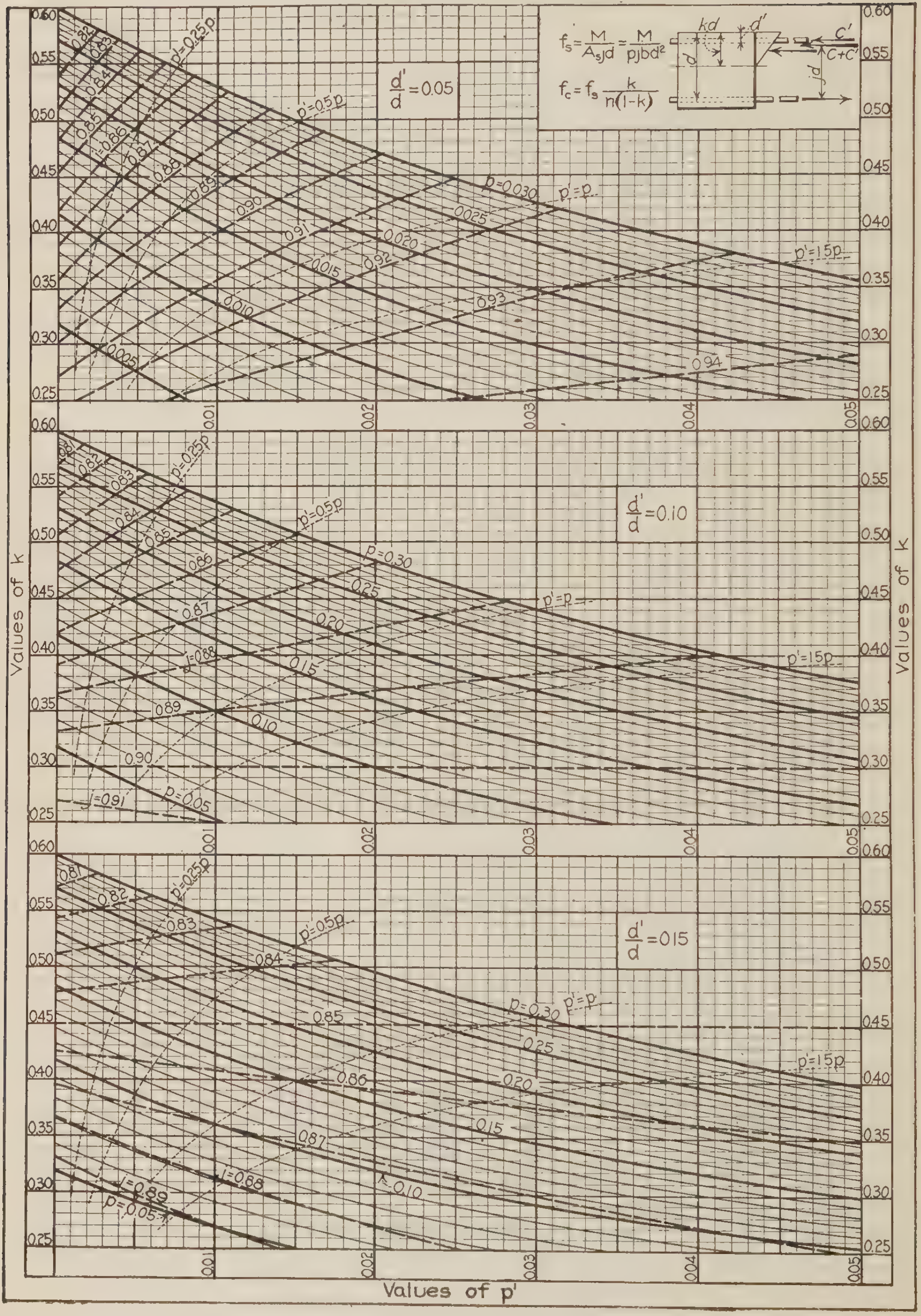
$\frac{d'}{d} = \frac{1}{10}$

$f_c = 850$
$f_s = 16{,}000$
$f_s = 18{,}000$
$n = 15$



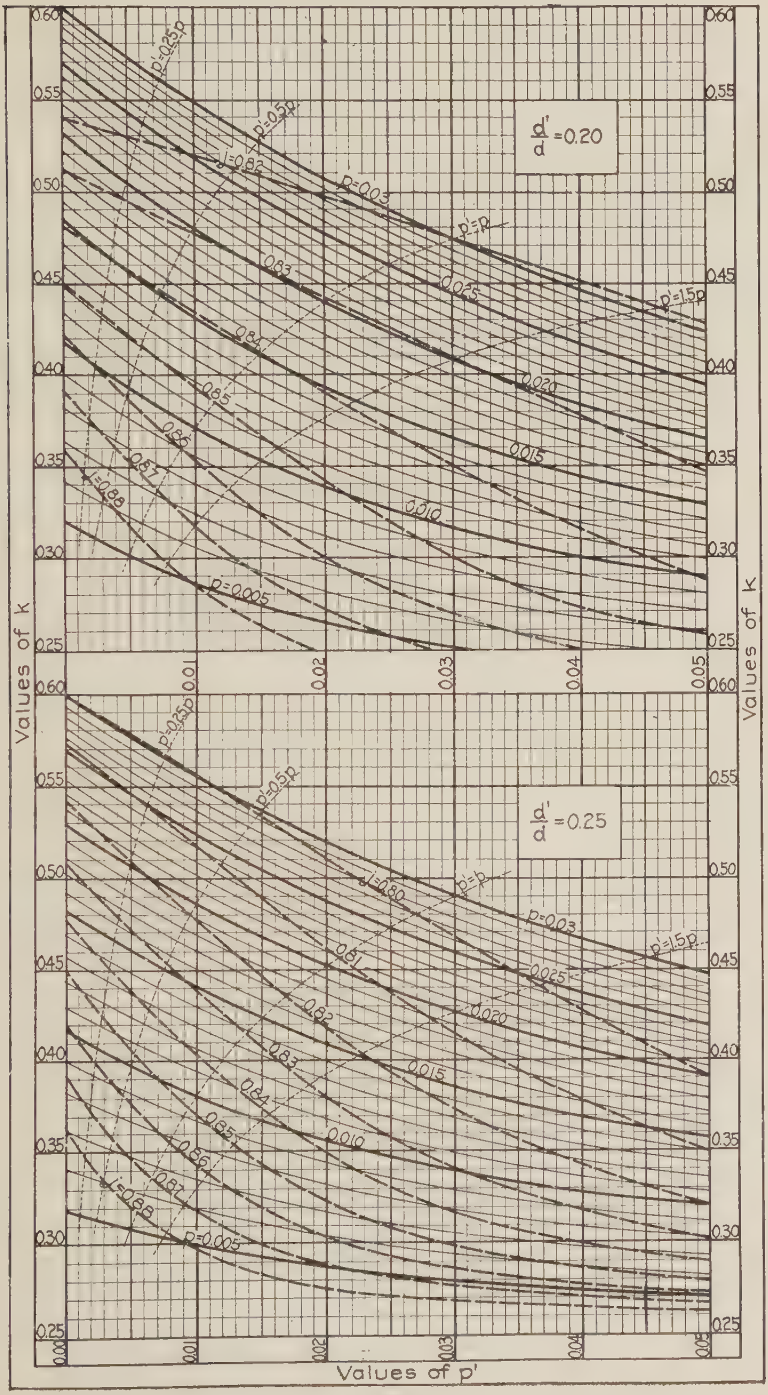
## DOUBLY REINFORCED RECTANGULAR BEAMS
## *VALUES OF k AND j*

*n = 15*



## DOUBLY REINFORCED RECTANGULAR BEAMS
## *VALUES OF k AND j*

*n* = *15*

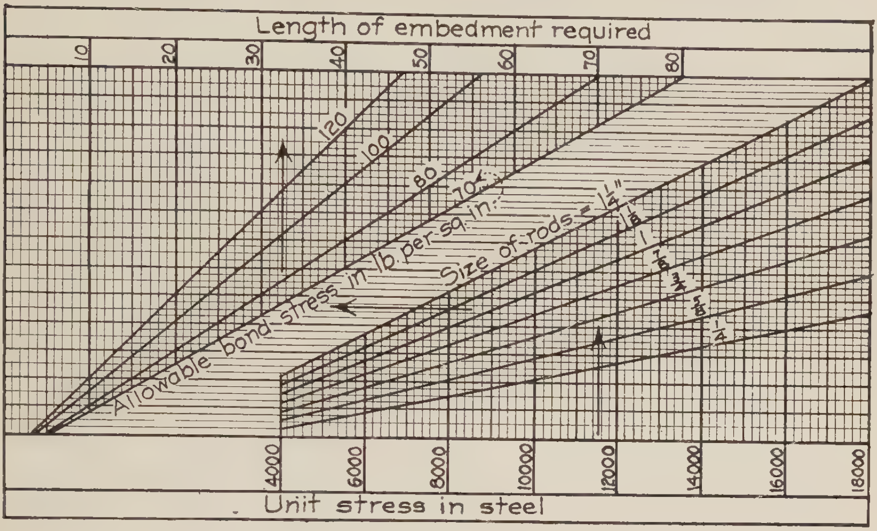


## VALUES OF $\frac{k}{k(1-n)}$ IN FORMULA $f_c = \frac{k}{n(1-k)} f_s$

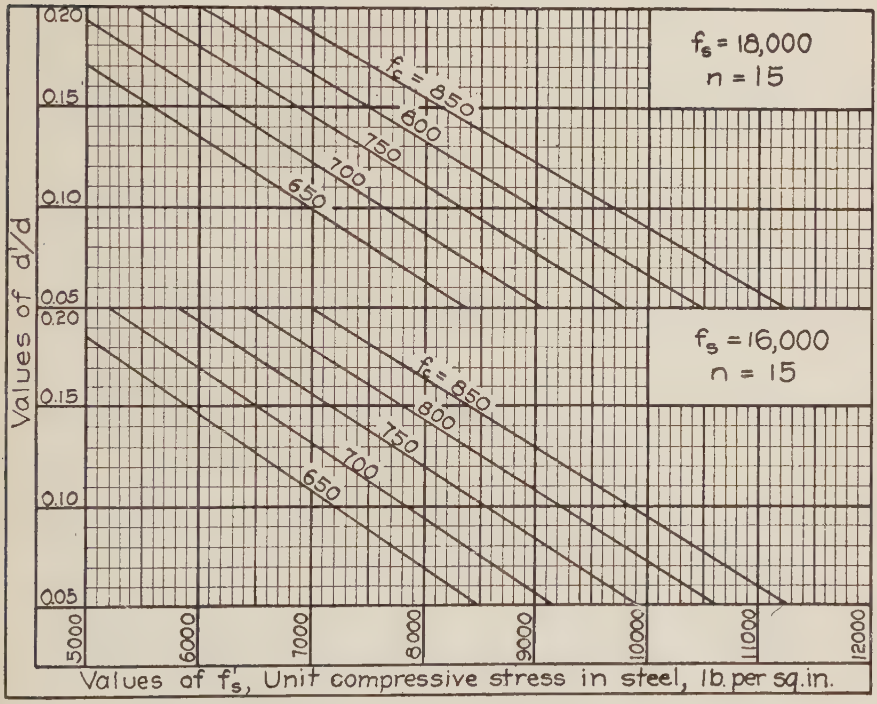
$n = 15$

| $k$ | $\frac{k}{n(1-k)}$ | $k$ | $\frac{k}{n(1-k)}$ | $k$ | $\frac{k}{n(1-k)}$ | $k$ | $\frac{k}{n(1-k)}$ | $k$ | $\frac{k}{n(1-k)}$ | $k$ | $\frac{k}{n(1-k)}$ | $k$ | $\frac{k}{n(1-k)}$ | $k$ | $\frac{k}{n(1-k)}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.200 | 0.0166 | 0.250 | 0.0222 | 0.300 | 0.0286 | 0.350 | 0.0359 | 0.400 | 0.0444 | 0.450 | 0.0545 | 0.500 | 0.0666 | 0.550 | 0.0815 |
| 0.202 | 0.0169 | 0.252 | 0.0224 | 0.302 | 0.0288 | 0.352 | 0.0362 | 0.402 | 0.0447 | 0.452 | 0.0549 | 0.502 | 0.0671 | 0.552 | 0.0821 |
| 0.204 | 0.0171 | 0.254 | 0.0226 | 0.304 | 0.0291 | 0.354 | 0.0365 | 0.404 | 0.0451 | 0.454 | 0.0554 | 0.504 | 0.0677 | 0.554 | 0.0827 |
| 0.206 | 0.0173 | 0.256 | 0.0229 | 0.306 | 0.0293 | 0.356 | 0.0368 | 0.406 | 0.0455 | 0.456 | 0.0558 | 0.506 | 0.0682 | 0.556 | 0.0834 |
| 0.208 | 0.0175 | 0.258 | 0.0231 | 0.308 | 0.0296 | 0.358 | 0.0371 | 0.408 | 0.0459 | 0.458 | 0.0562 | 0.508 | 0.0688 | 0.558 | 0.0841 |
| 0.210 | 0.0177 | 0.260 | 0.0234 | 0.310 | 0.0299 | 0.360 | 0.0375 | 0.410 | 0.0463 | 0.460 | 0.0567 | 0.510 | 0.0694 | 0.560 | 0.0848 |
| 0.212 | 0.0179 | 0.262 | 0.0236 | 0.312 | 0.0301 | 0.362 | 0.0378 | 0.412 | 0.0466 | 0.462 | 0.0571 | 0.512 | 0.0699 | 0.562 | 0.0855 |
| 0.214 | 0.0181 | 0.264 | 0.0238 | 0.314 | 0.0305 | 0.364 | 0.0381 | 0.414 | 0.0470 | 0.464 | 0.0576 | 0.514 | 0.0705 | 0.564 | 0.0862 |
| 0.216 | 0.0183 | 0.266 | 0.0241 | 0.316 | 0.0308 | 0.366 | 0.0384 | 0.416 | 0.0474 | 0.466 | 0.0581 | 0.516 | 0.0711 | 0.566 | 0.0869 |
| 0.218 | 0.0186 | 0.268 | 0.0243 | 0.318 | 0.0311 | 0.368 | 0.0387 | 0.418 | 0.0478 | 0.468 | 0.0586 | 0.518 | 0.0717 | 0.568 | 0.0876 |
| 0.220 | 0.0188 | 0.270 | 0.0246 | 0.320 | 0.0314 | 0.370 | 0.0391 | 0.420 | 0.0482 | 0.470 | 0.0591 | 0.520 | 0.0723 | 0.570 | 0.0884 |
| 0.222 | 0.0190 | 0.272 | 0.0248 | 0.322 | 0.0317 | 0.372 | 0.0394 | 0.422 | 0.0486 | 0.472 | 0.0595 | 0.522 | 0.0728 | 0.572 | 0.0891 |
| 0.224 | 0.0192 | 0.274 | 0.0251 | 0.324 | 0.0319 | 0.374 | 0.0398 | 0.424 | 0.0490 | 0.474 | 0.0600 | 0.524 | 0.0733 | 0.574 | 0.0898 |
| 0 226 | 0.0194 | 0.276 | 0.0254 | 0.326 | 0.0322 | 0.376 | 0.0401 | 0.426 | 0.0494 | 0.476 | 0.0605 | 0.526 | 0.0739 | 0.576 | 0.0905 |
| 0.228 | 0.0196 | 0.278 | 0.0257 | 0.328 | 0.0325 | 0.378 | 0.0404 | 0.428 | 0.0498 | 0.478 | 0.0610 | 0.528 | 0.0745 | 0.578 | 0.0912 |
| 0.230 | 0.0199 | 0.280 | 0.0259 | 0.330 | 0.0328 | 0.380 | 0.0408 | 0.430 | 0.0502 | 0.480 | 0.0615 | 0.530 | 0.0751 | 0.580 | 0.0920 |
| 0.232 | 0.0201 | 0.282 | 0.0261 | 0.332 | 0.0331 | 0.382 | 0.0411 | 0.432 | 0.0506 | 0.482 | 0.0620 | 0.532 | 0.0757 | 0.582 | 0.0927 |
| 0.234 | 0.0203 | 0.284 | 0.0264 | 0.334 | 0.0334 | 0.384 | 0.0415 | 0.434 | 0.0511 | 0.484 | 0.0625 | 0.534 | 0.0763 | 0.584 | 0.0935 |
| 0.236 | 0.0205 | 0.286 | 0.0267 | 0.336 | 0.0337 | 0.386 | 0.0419 | 0.436 | 0.0515 | 0.486 | 0.0630 | 0.536 | 0.0770 | 0.586 | 0.0943 |
| 0.238 | 0.0207 | 0.288 | 0.0269 | 0.338 | 0.0340 | 0.388 | 0.0422 | 0.438 | 0.0520 | 0.488 | 0.0635 | 0.538 | 0.0776 | 0.588 | 0.0951 |
| 0.240 | 0.0210 | 0.290 | 0.0272 | 0.340 | 0.0344 | 0.390 | 0.0426 | 0.440 | 0.0524 | 0.490 | 0.0640 | 0.540 | 0.0783 | 0.590 | 0.0959 |
| 0.242 | 0.0212 | 0.292 | 0.0275 | 0.342 | 0.0347 | 0.392 | 0.0429 | 0.442 | 0.0528 | 0.492 | 0.0645 | 0.542 | 0.0789 | 0.592 | 0.0967 |
| 0.244 | 0.0214 | 0.294 | 0.0278 | 0.344 | 0.0350 | 0.394 | 0.0433 | 0.444 | 0.0532 | 0.494 | 0.0650 | 0.544 | 0.0795 | 0.594 | 0.0975 |
| 0.246 | 0.0217 | 0.296 | 1.0280 | 0.346 | 0.0353 | 0.396 | 0.0437 | 0.446 | 0.0536 | 0.496 | 0.0656 | 0.546 | 0.0802 | 0.596 | 0.0984 |
| 0.248 | 0.0219 | 0.298 | 0.0283 | 0.348 | 0.0356 | 0.398 | 0.0440 | 0.488 | 0.0540 | 0.498 | 0.0660 | 0.548 | 0.0808 | 0.598 | 0.0993 |

## LENGTH OF EMBEDMENT OF RODS IN COMPRESSION



## UNIT STRESS IN COMPRESSIVE STEEL



# SECTION 5

## T-BEAMS

Diagrams 33 and 34 should be used for designing T-beams when the neutral axis is in the stem and when the compression in the stem is to be neglected. The left hand side of the diagram gives the values of $\frac{M}{bd^2}$, $f_c$, and $\frac{t}{d}$. The right hand side gives values of $j$ and $p$, to be used in finding the area of steel required.

Diagram 35* is for general use and may be employed either for design or for determining stresses in existing designs.

### Design of T-Beams

*Assuming* $f_s = 16{,}000$, $f_c = 650$, $n = 15$, $t = 5\frac{1}{2}$ *in., and* $M = 3{,}000{,}000$ *in.-lb., find the section of stem required.*

Consider the stem width to be 12 in., and the width of flange as found from the Joint Committee recommendations to be 56 in.

To obtain the value of $\frac{M}{bd^2}$, it is necessary to know the value of $\frac{t}{d}$. Since this is unknown it must be assumed. For $\frac{t}{d} = 0.2$, Diagram 33 shows $\frac{M}{bd^2} = 87.6$, and

$$d = \sqrt{\frac{3{,}000{,}000}{(56)(87.6)}} = 24.8 \text{ in. and } \frac{t}{d} = \frac{5.5}{24.8} = 0.222$$

Taking $\frac{t}{d} = 0.23$, $\frac{M}{bd^2} = 94$, and

$$d = \sqrt{\frac{3{,}000{,}000}{(56)(94)}} = 23.9 \text{ or } 24 \text{ in. and } \frac{t}{d} = 0.229$$

The required depth therefore is 24 in.

Entering the right hand side of Diagram 33 with $\frac{t}{d} = 0.229$ and $K = 93$, it is found that $j = 0.902$, and

$$A_s = \frac{M}{f_s jd} = \frac{3{,}000{,}000}{(16{,}000)(0.902)(24)} = 8.66 \text{ sq. in.}$$

Diagram 35 may also be used in making this design. The value of $\frac{t}{d}$ is assumed as before. Entering at the lower right hand scale with $f_s = 16{,}000$, follow vertically to $f_c = 650$ and then to the left to $\frac{t}{d} = 0.23$. The percentage of steel is 0.0065. Now follow vertically along $\frac{t}{d} = 0.23$ to $p = 0.0065$ in the upper left hand part of the diagram. From there follow to the right to $f_s = 16{,}000$ and then vertically to obtain the value of $\frac{M}{bd^2} = 94$.

$$d = \sqrt{\frac{3{,}000{,}000}{(56)(94)}} = 24 \text{ in.}$$

$$A_s = pbd = (0.0065)(56)(24) = 8.74 \text{ sq. in.}$$

---

* From Vol. I of "Bridge Engineering," by Waddell.

Usually the section of the stem of a T-beam is controlled by the shearing stresses. The procedure in ordinary building design is to design the stem to take the shear at the support and then determine the concrete stress in the flange at the center of span, using the value of $\frac{t}{d}$ already determined.

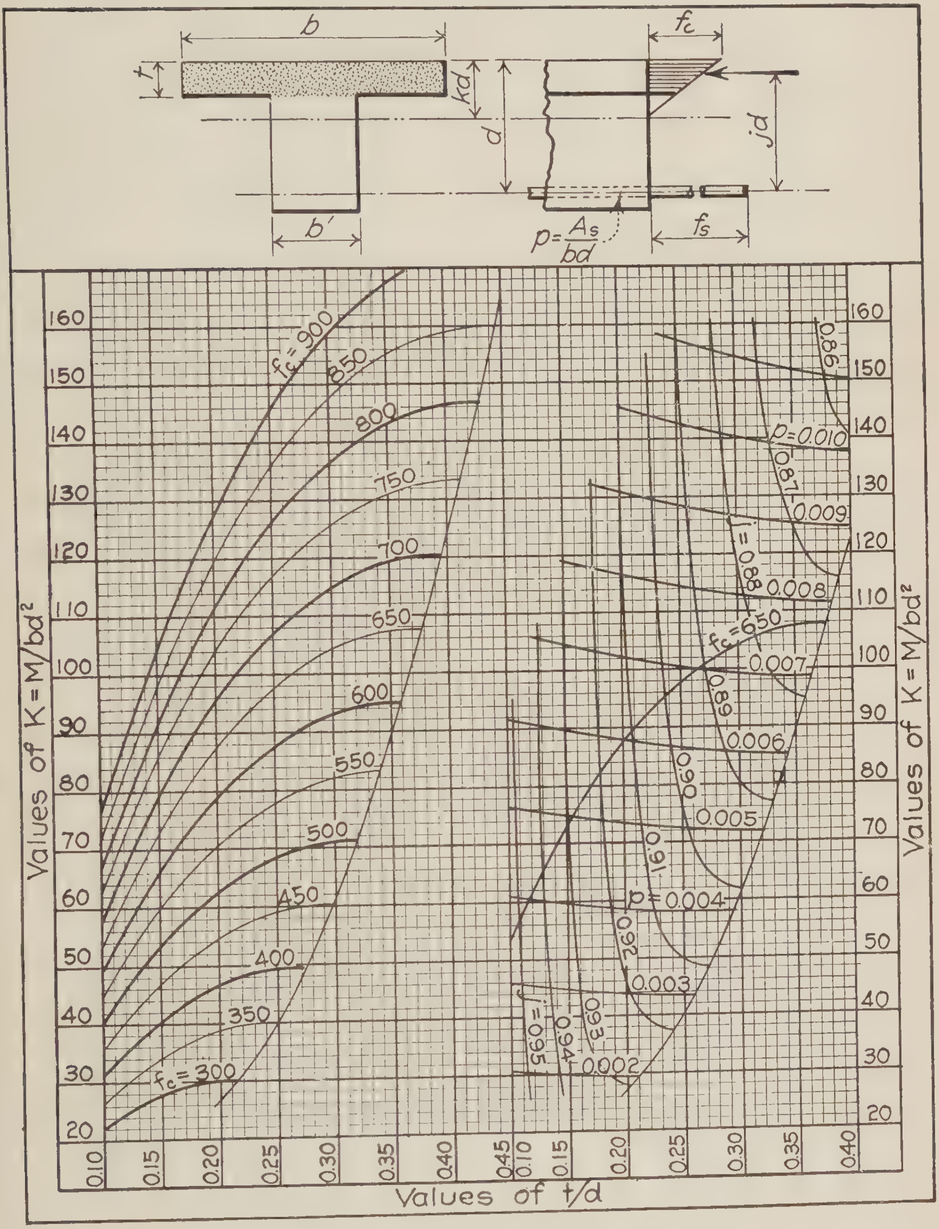
## Reviewing T-Beams

In reviewing a beam already designed, the values of $\frac{M}{bd^2}$, $\frac{t}{d}$, and $p$ are known. From these the value of $f_s$ is found from the upper half of Diagram 35. Then using the values of $\frac{t}{d}$, $p$ and $f_s$, the value of $f_c$ is found from the lower half of this diagram.

## DESIGN OF T-BEAMS

### VALUES OF $\frac{M}{bd^2}$, $\frac{t}{d}$, $f_c$, $p$, AND $j$

$f_s = 16{,}000$
$n = 15$



T-BEAMS

## DESIGN OF T-BEAMS

$f_s = 18{,}000$
$n = 15$

## VALUES OF $\frac{M}{bd^2}$, $\frac{t}{d}$, $f_c$, $p$, AND $j$

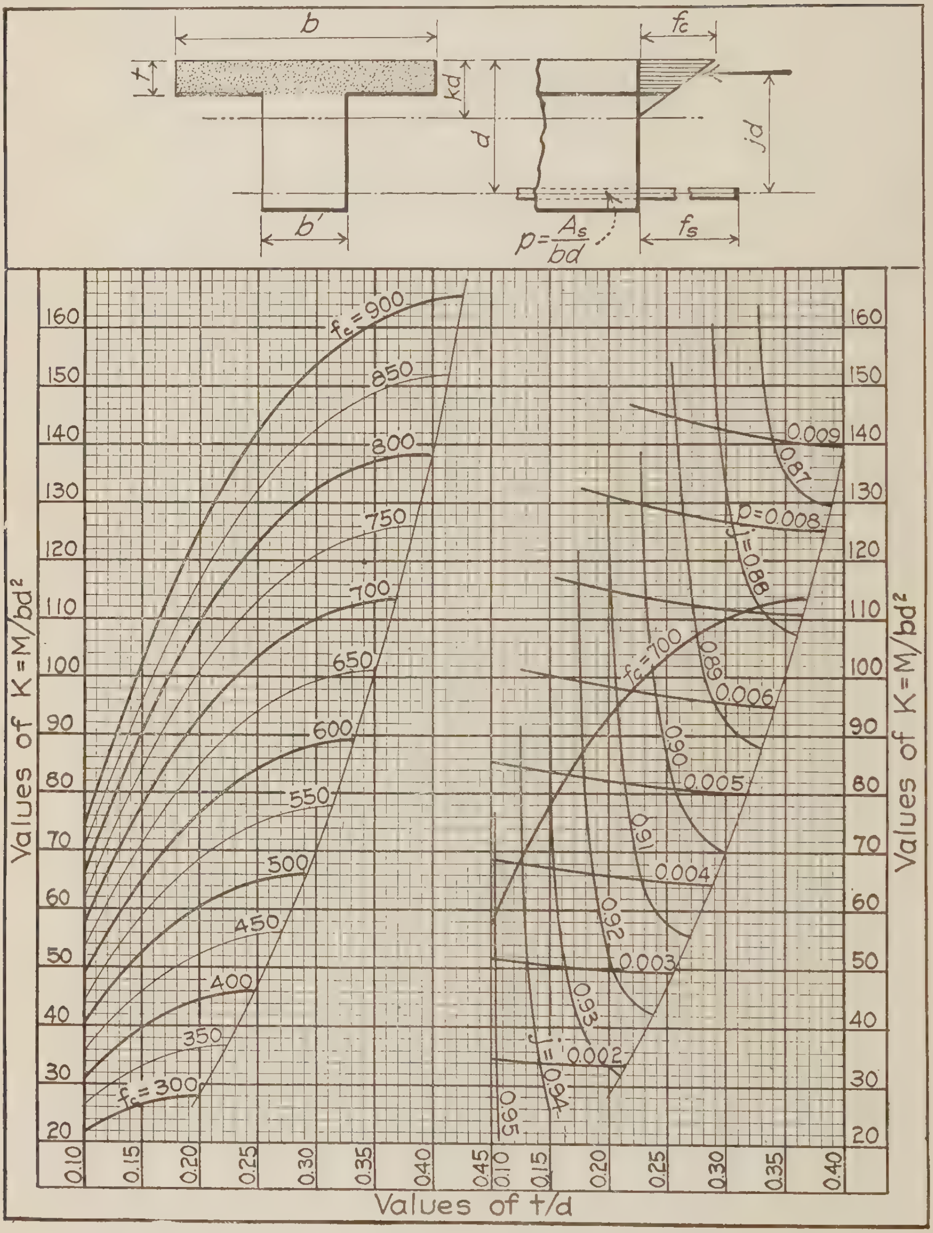
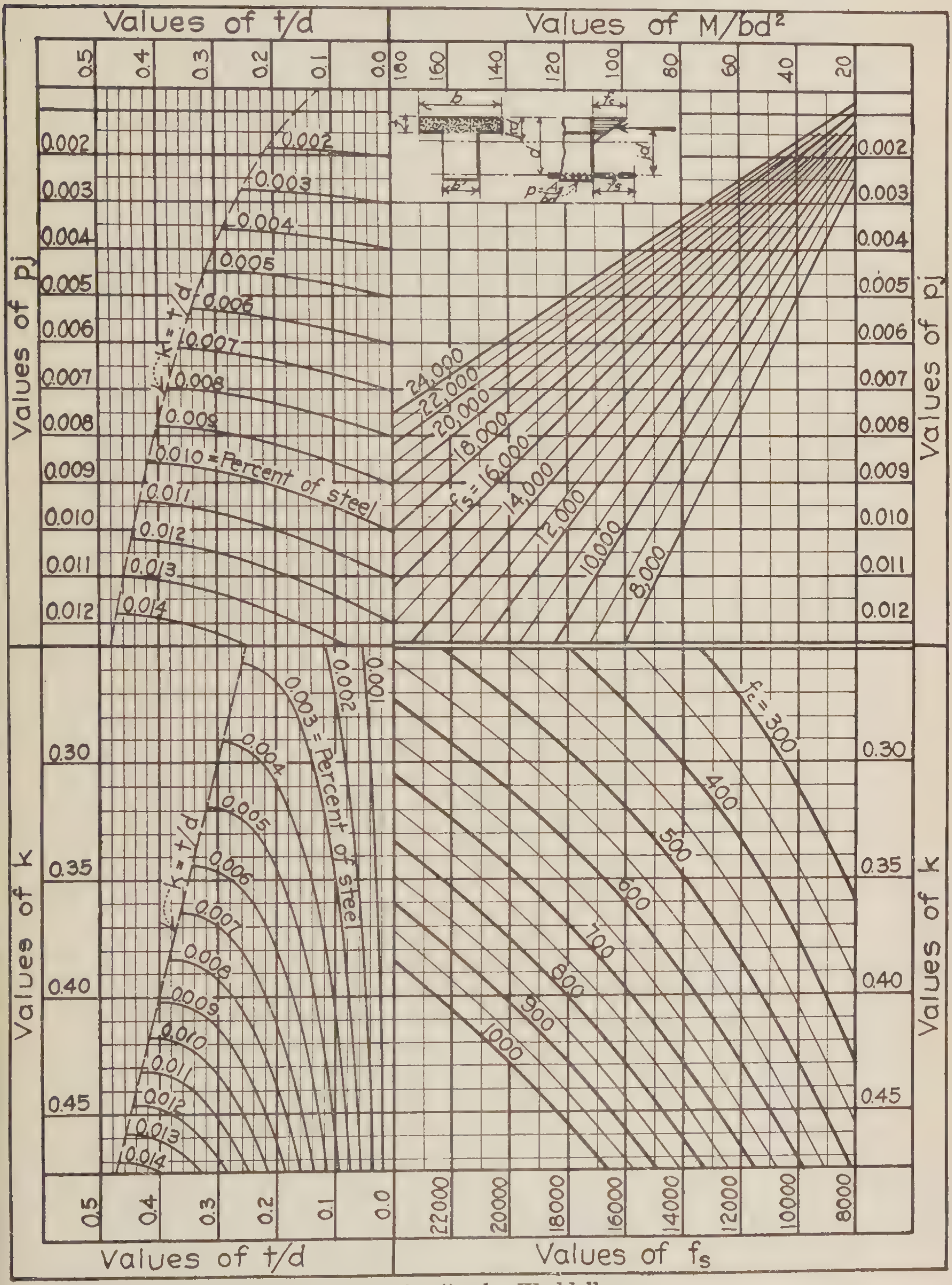


DIAGRAM 35

## DESIGN OR REVIEW OF T-BEAMS*

$n = 15$



* From Vol. 1 of "Bridge Engineering,"— by Waddell.

## SECTION 6

## SHEAR REINFORCEMENT

Diagram 36 may be used to find unit shear or bond stress for any beam.

### Uniformly Loaded Beams

Diagram 37 gives the total number of stirrups in each end of a uniformly loaded beam, assuming the concrete to take one-third of the total shear, as recommended by the Joint Committee. The total number of stirrups at each end of beam is found by entering the diagram with the unit shear at the support and the clear span in feet, and following the directions of the arrows to the upper left hand part of the diagram. Note that Diagram 37 is made for U-stirrups only with the exception of the ¼-in. W-stirrup which has a total cross-sectional area equal to the 5⁄16-in. square U-stirrup. The number of W-stirrups required in any given case will be one-half the number of U-stirrups of the same size.

Diagram 38 gives the distance ($l'$) from the face of support to the point where $v = 40$ lb. per sq. in., beyond which no stirrups are required.

Diagram 39 is used for locating the stirrups in the beam. It is so constructed that if any one of the horizontal light lines is assumed to pass through the face of the support and the top line marked "center of span" is assumed to pass through the center of span, the intermediate light lines will divide the triangular shear diagram into equal areas and the heavy lines will pass through the centers of gravity of these areas. The heavy lines therefore represent the location of the stirrups.

A convenient scale is placed with the zero on the fine line marked with a number corresponding to $N_s$. The scale is then rotated until it reads $\frac{l}{2}$ (in inches) at the top line (center of span line). The distances from the face of support to the heavy lines are then read directly from the scale, stopping when $l'$ is reached. One side of a triangular engineers' scale may be used for all ordinary cases.

*Required to space* ⅜*-in. round U-stirrups in a beam* 10 *in. wide and of* 18*-ft. clear span, having a shear at the support of* 118 *lb. per sq. in.*

From Diagram 37

$$N_s = 12$$

From Diagram 38

$$l' = 71 \text{ in.}$$

Placing scale on Diagram 39 to read zero at $N_s = 12$ and 108 on line marked "center of span," the distances in inches from the face of support to the points where stirrups should be placed are: 2½, 7, 12, 17, 22½, 28½, 35, 42, 50, 59, and 70. This theoretical spacing will usually be modified by practical considerations, such as the maximum spacing allowable for the depth of beam. The spacing of stirrups should not be greater than about one-half the beam depth.

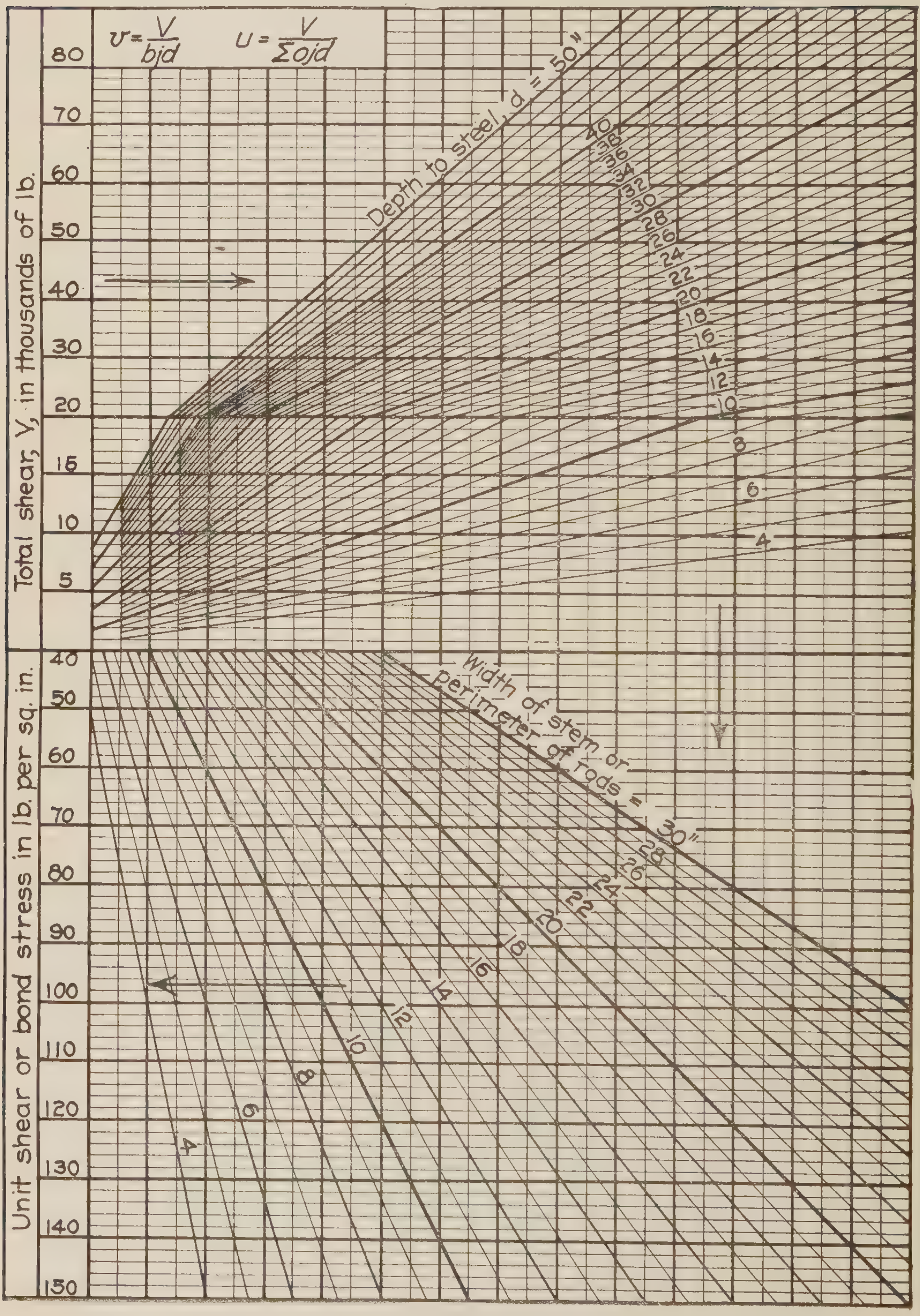
### Beams with Concentrated Loads

Diagrams 40 and 41 may be used to find the theoretical spacing of stirrups for beams with concentrated loads, the concrete assumed to take one-third of the total shear. Diagram 40 is based on unit shear and Diagram 41 on total shear. The spacing of stirrups will ordinarily be made uniform between load concentrations.

DIAGRAM 36

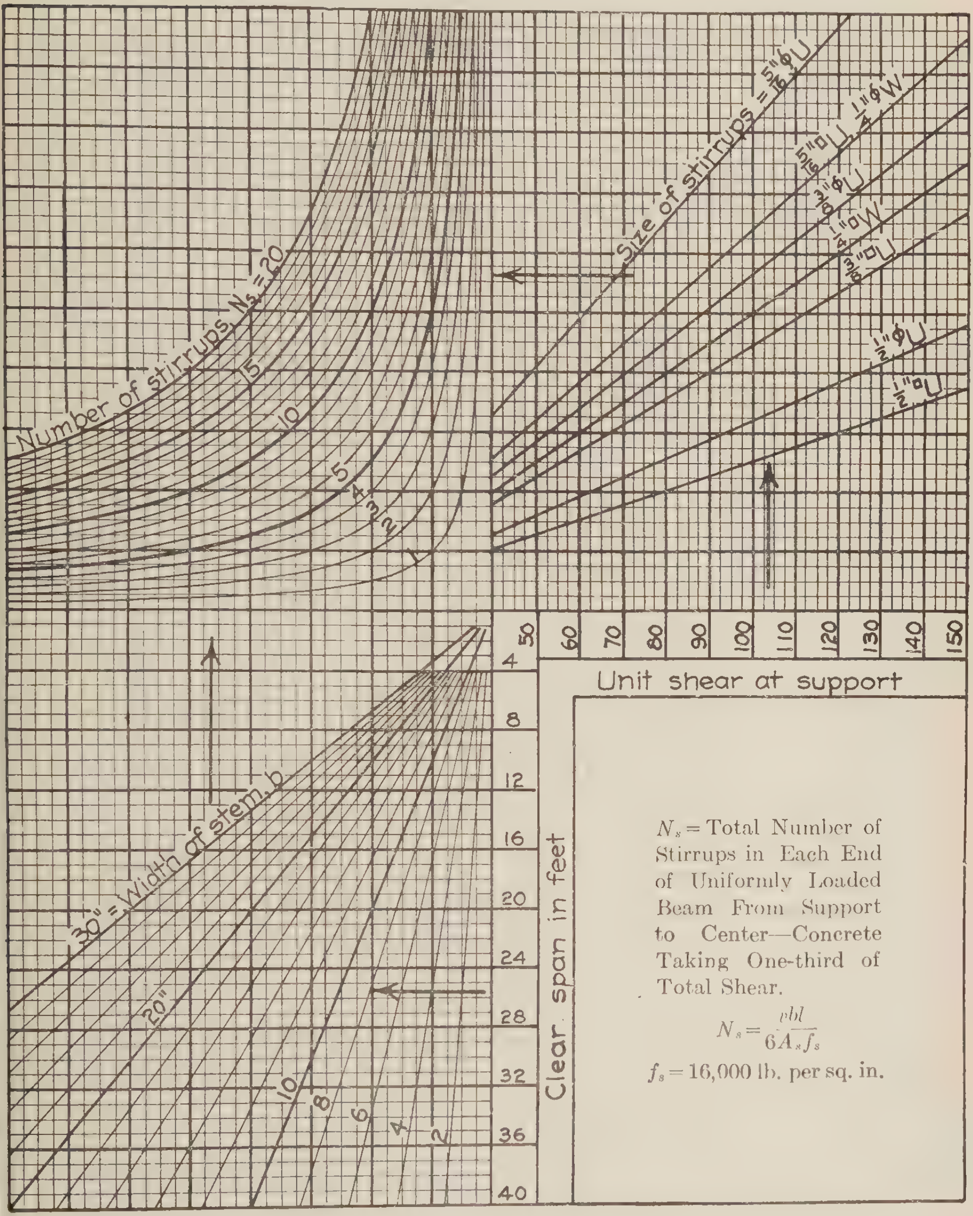
## UNIT SHEAR AND BOND STRESS

$j = 0.875$



## STIRRUPS FOR UNIFORMLY LOADED BEAM

$f_s = 16{,}000$

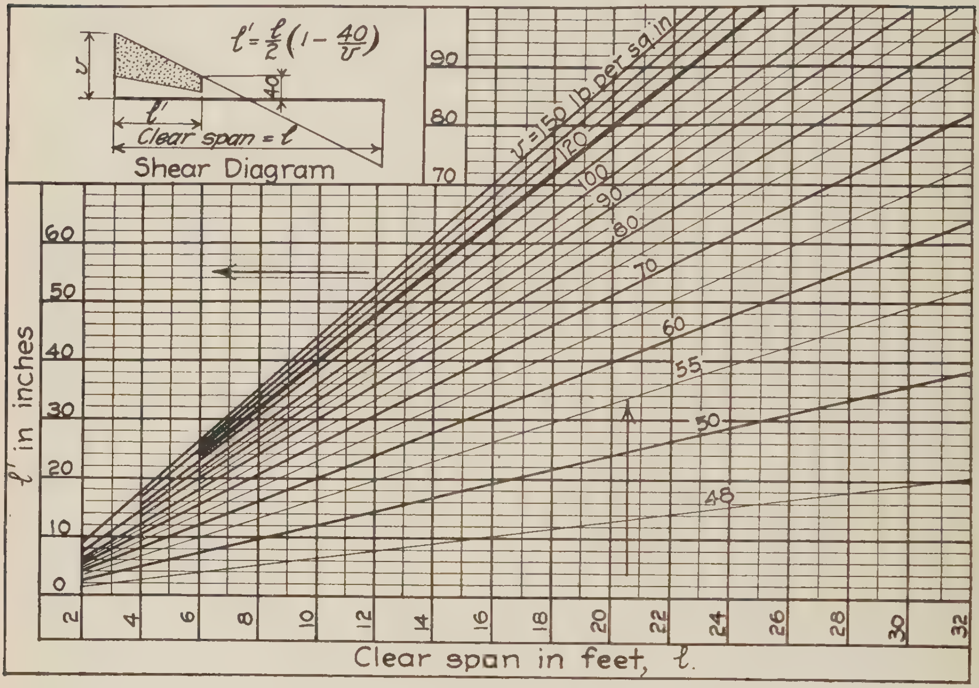


$N_s$ = Total Number of Stirrups in Each End of Uniformly Loaded Beam From Support to Center—Concrete Taking One-third of Total Shear.

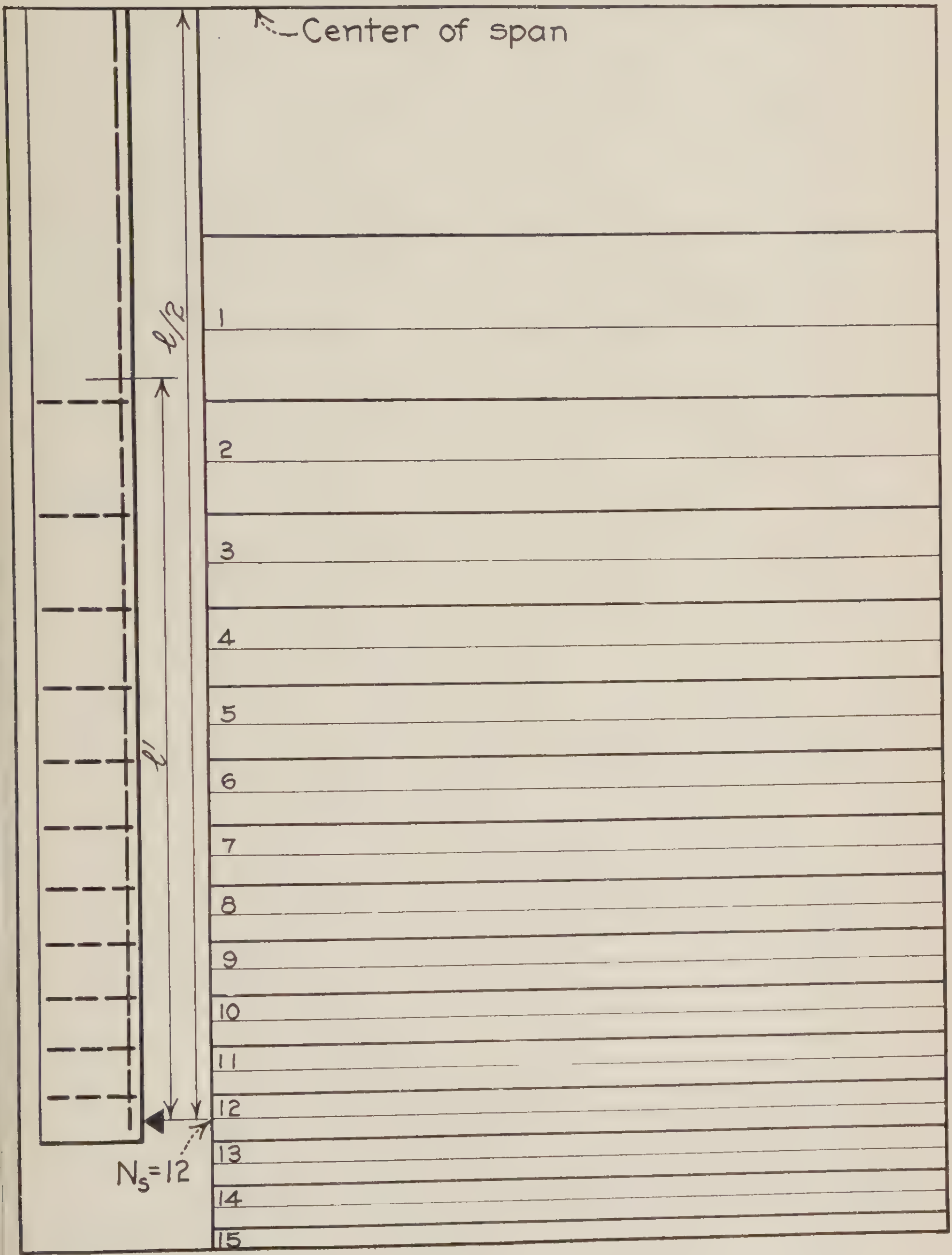
$$N_s = \frac{vbl}{6A_s f_s}$$

$f_s$ = 16,000 lb. per sq. in.

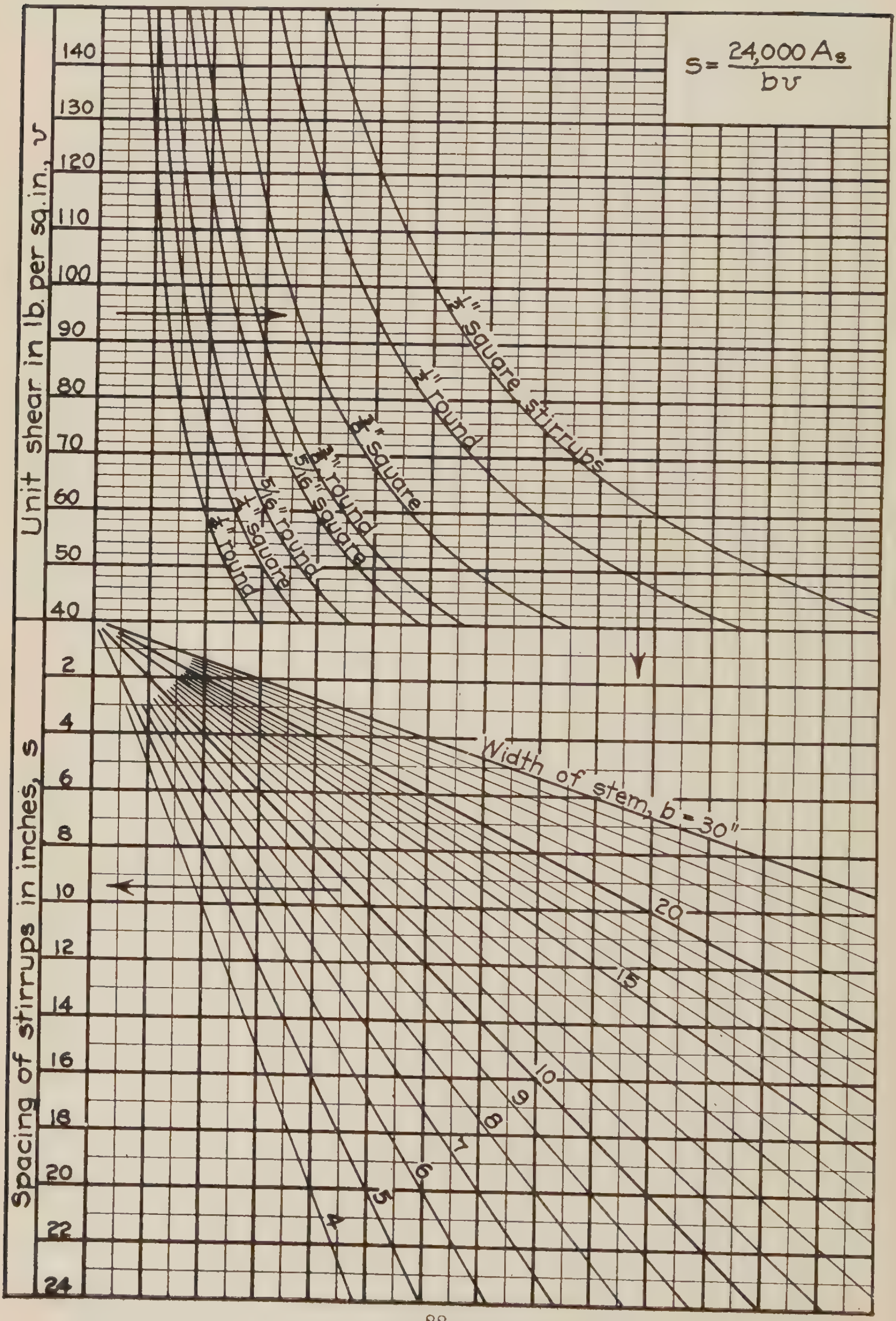
## UNIFORMLY LOADED BEAMS
## LENGTH OF BEAM REQUIRING SHEAR REINFORCEMENT



# DIAGRAM FOR LOCATING STIRRUPS IN UNIFORMLY LOADED BEAMS



## SPACING OF U-STIRRUPS
## CONCRETE TAKING ONE-THIRD OF TOTAL SHEAR
## $f_s = 16,000$

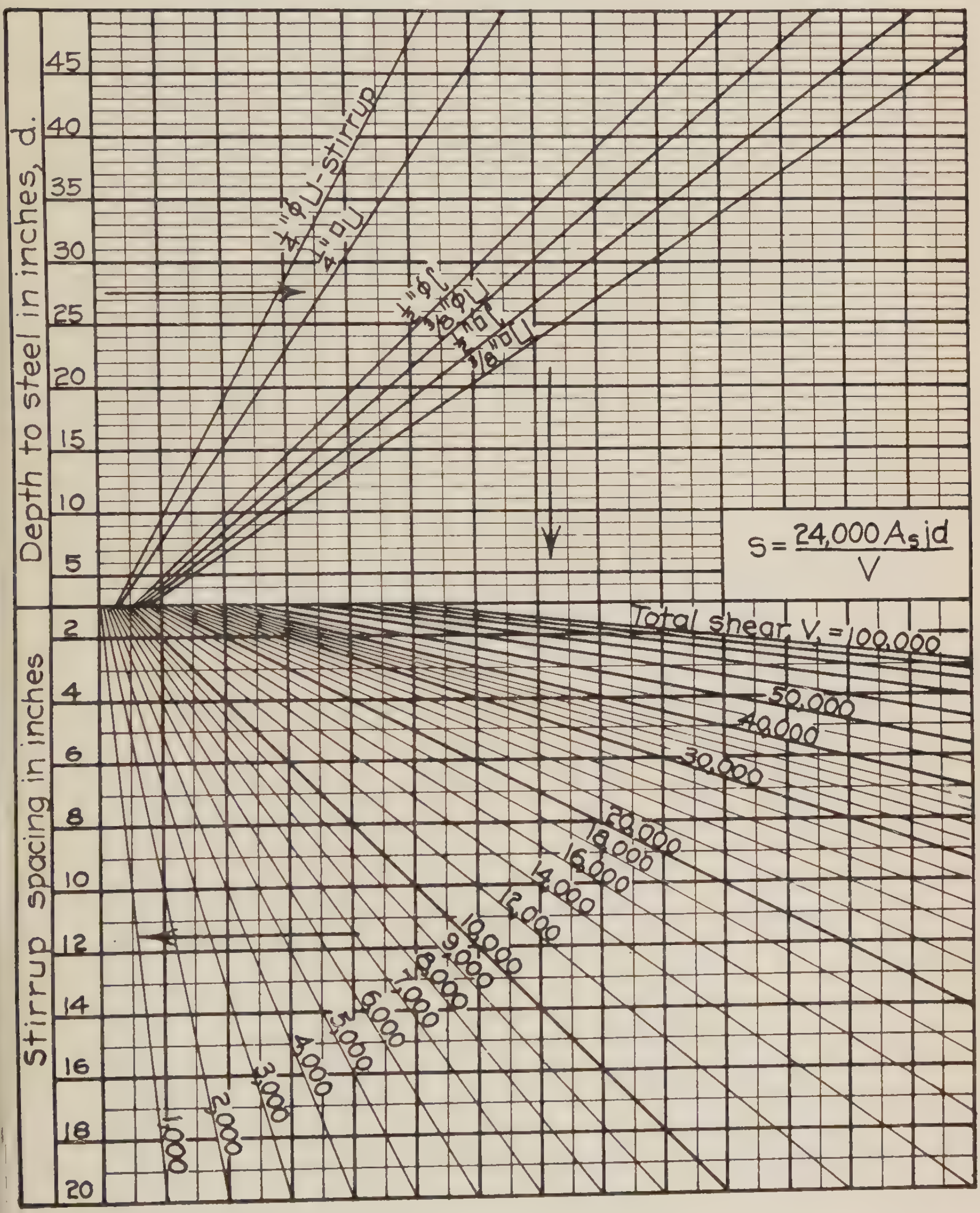


SHEAR
REINFORCEMENT

## SPACING OF STIRRUPS

## CONCRETE TAKING ONE-THIRD OF TOTAL SHEAR

$f_s = 16,000$



## SECTION 7

## COLUMNS

The following tables of safe loads on columns are based on the requirements of the respective codes in regard to maximum and minimum percentages of vertical steel and spiral, and also on such practical considerations as the minimum spacing of vertical steel. The number of rods in the square cored columns is limited to eight because every rod should be tied back into the column by the binders and it is ordinarily better practice to use a spiraled column if more than eight rods are found necessary.

The tables for round cored hooped columns are so complete that it should be possible to select a satisfactory design for any condition of concentric loading without additional computation. The values of safe loads given in Tables 35 to 42 inclusive are based on the percentages of spiral listed and, if desired, another spiral of equal volume may be substituted from Table 46.

Diagrams 42 and 43 will be found valuable for determining building column loads for preliminary work.

For the design of columns which are eccentrically loaded, see Section 8. Diagrams for the design of round columns subjected to bending and direct stress have been constructed and are published here for the first time.

*What size of square cored column and what amount of longitudinal steel will be required to support a centrally applied load of 200,000 lb., assuming the recommendations of the Joint Committee to govern? Ratio of unsupported length of column to column side is less than* 15.

Tables 21, 22 and 23 show the following possible designs:

2000-*lb. concrete.*

| | |
|---|---|
| 22-in. column | 6-1¼ in. square<br>8-1⅛ in. square |
| 23-in. column | 6-1 in. square<br>8-1 in. round |

2500-*lb. concrete.*

| | |
|---|---|
| 20-in. column | 6-1¼ in. square<br>8-1⅛ in. square |
| 21-in. column | 6-1 in. square<br>8-1 in. round |

3000-*lb. concrete.*

| | |
|---|---|
| 19-in. column | 8-1⅛ in. round |
| 20-in. column | 8-¾ in. square<br>6-1 in. round |

Lateral ties must be used of not less than ¼ in. in diameter and spaced not over 12 in. apart. For ⅝-in. rods the spacing should never be more than 10 in.

*What size of round column and what amount of longitudinal steel will be required by the Joint Committee Recommendations to support a load of* 1,100,000 *lb.? A* 3000-lb. *concrete is to be used with* 1% *of spiral reinforcement. Unsupported length of column is less than* 10 *diameters.*

From Table 34, page 114, it is found that a 37-in. round column with 33-in. core, and with fourteen 1¼-in. square longitudinal rods will safely support a load of 1,105,000 lb.

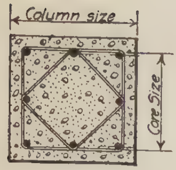
Table 47 shows that a spiral of 7/0 gage and 2¼-in. pitch will give 1% of reinforcement; or that a ½-in. spiral may be used with 2⅜-in. pitch. Table 46, page 188, gives other satisfactory sizes and pitch of spirals to obtain the required 1% of spiral reinforcement. This table also gives the weight in pounds per foot of column for each spiral. Table 45 gives the volume and weight of columns per foot and Table 44 gives the weights of column rods per foot.

*What would be the design of the column of the preceding problem assuming the American Concrete Institute recommendations to govern?*

A number of satisfactory designs may be taken from Table 37. One possible design is to use a 37-in. column with 33-in. core and a spiral of 7/0 gage, 2¼-in. pitch, sixteen 1¼-in. round longitudinal rods.

**Reduction Formula for Long Columns.**—Where long columns must be used, the reduction which follows, taken from the Los Angeles Building Code, may be employed in the design of columns whose unsupported length ($l$) is between 15 and 30 times the least dimension of effective section ($d$). Let $r$ represent the quantity by which the working stress for columns with $\frac{l}{d}$ less than 15 should be multiplied to give a working stress which may be used for long columns. Then

$$r = 1.6 - \tfrac{1}{25}\left(\frac{l}{d}\right)$$



# SQUARE CORED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## JOINT COMMITTEE RECOMMENDATIONS

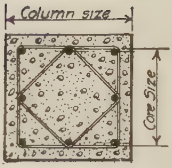
$$P = Af_c[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{side}}\right) = 15$$

*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 450$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 8 | 4 | 38.6 | 43.0 | ..... | ..... | ..... | ..... | 36.5 | 40.0 | 44.0 | | | |
| 13 | 9 | 4 | 46.3 | 50.6 | 55.7 | ..... | ..... | ..... | 44.2 | 47.6 | 51.6 | 56.2 | | |
| 14 | 10 | 4 | 54.8 | 59.2 | 64.3 | 70.2 | ..... | ..... | 52.7 | 56.2 | 60.2 | 64.8 | 70.1 | |
| | | 6 | 59.7 | 66.3 | ..... | ..... | ..... | ..... | 56.6 | 61.7 | 67.7 | | | |
| | | 8 | 64.7 | ..... | ..... | ..... | ..... | ..... | 60.4 | 67.2 | | | | |
| 15 | 11 | 4 | 64.3 | 68.6 | 73.7 | 79.7 | ..... | ..... | 62.2 | 65.6 | 69.6 | 74.2 | 79.5 | |
| | | 6 | 69.2 | 75.7 | 83.4 | ..... | ..... | ..... | 66.0 | 71.1 | 77.2 | 84.1 | | |
| | | 8 | 74.1 | 82.8 | ..... | ..... | ..... | ..... | 69.9 | 76.7 | 84.8 | | | |
| 16 | 12 | 4 | 74.6 | 79.0 | 84.1 | 90.0 | 96.1 | ..... | ..... | 76.0 | 80.0 | 84.6 | 89.9 | 95.7 |
| | | 6 | 79.5 | 86.1 | 93.7 | ..... | ..... | ..... | 76.4 | 81.5 | 87.5 | 94.5 | | |
| | | 8 | 84.5 | 93.2 | ..... | ..... | ..... | ..... | 80.2 | 87.0 | 95.1 | | | |
| 17 | 13 | 4 | ..... | 90.2 | 95.3 | 101.3 | 107.9 | 115.4 | ..... | 87.2 | 91.2 | 95.8 | 101.1 | 107.0 |
| | | 6 | 90.8 | 97.3 | 105.0 | 113.9 | ..... | ..... | 87.6 | 92.7 | 98.8 | 105.7 | 113.6 | |
| | | 8 | 95.7 | 104.4 | 114.6 | ..... | ..... | ..... | 91.5 | 98.3 | 106.4 | 115.6 | | |
| 18 | 14 | 4 | ..... | 102.4 | 107.5 | 113.4 | 120.1 | 127.6 | ..... | ..... | 103.4 | 108.0 | 113.3 | 119.1 |
| | | 6 | 102.9 | 109.5 | 117.1 | 126.0 | 136.0 | ..... | ..... | 104.9 | 110.9 | 117.9 | 125.7 | 134.6 |
| | | 8 | 107.9 | 116.6 | 126.8 | ..... | ..... | ..... | 103.6 | 110.4 | 118.5 | 127.8 | ..... | ..... |
| 19 | 15 | 4 | ..... | 115.4 | 120.5 | 126.5 | 133.1 | 140.6 | ..... | ..... | 116.4 | 121.0 | 126.3 | 132.2 |
| | | 6 | 116.0 | 122.5 | 130.2 | 139.1 | 149.1 | ..... | ..... | 117.9 | 124.0 | 130.9 | 138.8 | 147.6 |
| | | 8 | 120.9 | 129.6 | 139.8 | 151.7 | ..... | ..... | 116.7 | 123.5 | 131.6 | 140.8 | 151.3 | |
| 20 | 16 | 4 | ..... | ..... | 134.5 | 140.4 | 147.1 | 154.6 | ..... | ..... | ..... | 135.0 | 140.3 | 146.1 |
| | | 6 | ..... | 136.5 | 144.1 | 153.0 | 163.0 | 174.3 | ..... | 131.9 | 137.9 | 144.9 | 152.8 | 161.6 |
| | | 8 | 134.9 | 143.6 | 153.8 | 165.6 | 179.0 | ..... | ..... | 137.4 | 145.5 | 154.8 | 165.3 | 177.1 |
| 21 | 17 | 4 | ..... | ..... | 149.3 | 155.3 | 161.9 | 169.4 | ..... | ..... | ..... | 149.8 | 155.1 | 161.0 |
| | | 6 | ..... | 151.3 | 159.0 | 167.9 | 177.9 | 189.1 | ..... | ..... | 152.8 | 159.7 | 167.6 | 176.4 |
| | | 8 | 149.7 | 158.4 | 168.6 | 180.5 | 193.8 | ..... | ..... | 152.3 | 160.4 | 169.6 | 180.1 | 191.9 |
| 22 | 18 | 4 | ..... | ..... | ..... | 171.0 | 177.7 | 185.2 | ..... | ..... | ..... | ..... | 170.9 | 176.7 |
| | | 6 | ..... | 167.1 | 174.7 | 183.6 | 193.6 | 204.9 | ..... | ..... | 168.5 | 175.5 | 183.3 | 192.2 |
| | | 8 | ..... | 174.2 | 184.4 | 196.2 | 209.6 | 224.6 | ..... | 168.0 | 176.1 | 185.4 | 195.9 | 207.7 |
| 23 | 19 | 4 | ..... | ..... | ..... | 187.7 | 194.3 | 201.8 | ..... | ..... | ..... | ..... | 187.5 | 193.4 |
| | | 6 | ..... | ..... | 191.4 | 200.3 | 210.3 | 221.5 | ..... | ..... | 185.2 | 192.1 | 200.0 | 208.8 |
| | | 8 | ..... | 190.8 | 201.0 | 212.9 | 226.2 | 241.2 | ..... | ..... | 192.8 | 202.0 | 212.5 | 224.3 |
| 24 | 20 | 4 | ..... | ..... | ..... | 205.2 | 211.9 | 219.4 | ..... | ..... | ..... | ..... | 205.1 | 210.9 |
| | | 6 | ..... | ..... | 208.9 | 217.8 | 227.8 | 239.1 | ..... | ..... | ..... | 209.7 | 217.5 | 226.4 |
| | | 8 | ..... | 208.4 | 218.6 | 230.4 | 243.8 | 258.8 | ..... | ..... | 210.3 | 219.6 | 230.1 | 241.9 |
| 25 | 21 | 4 | ..... | ..... | ..... | ..... | 230.3 | 237.8 | ..... | ..... | ..... | ..... | ..... | 229.4 |
| | | 6 | ..... | ..... | 227.4 | 236.3 | 246.3 | 257.5 | ..... | ..... | ..... | 228.1 | 236.0 | 244.8 |
| | | 8 | ..... | 226.8 | 237.0 | 248.9 | 262.2 | 277.2 | ..... | ..... | 228.8 | 238.0 | 248.5 | 260.3 |
| 26 | 22 | 4 | ..... | ..... | ..... | ..... | 249.7 | 257.2 | ..... | ..... | ..... | ..... | ..... | 248.7 |
| | | 6 | ..... | ..... | ..... | 255.6 | 265.6 | 276.9 | ..... | ..... | ..... | ..... | 255.3 | 264.2 |
| | | 8 | ..... | ..... | 256.4 | 268.2 | 281.6 | 296.6 | ..... | ..... | ..... | 257.4 | 267.9 | 279.7 |
| 27 | 23 | 4 | ..... | ..... | ..... | ..... | ..... | 277.4 | | | | | | |
| | | 6 | ..... | ..... | ..... | 275.9 | 285.9 | 297.1 | ..... | ..... | ..... | ..... | 275.6 | 284.4 |
| | | 8 | ..... | ..... | 276.6 | 288.5 | 301.8 | 316.8 | ..... | ..... | ..... | 277.6 | 288.1 | 299.9 |
| 28 | 24 | 4 | ..... | ..... | ..... | ..... | ..... | 298.6 | | | | | | |
| | | 6 | ..... | ..... | ..... | 297.0 | 307.0 | 318.3 | ..... | ..... | ..... | ..... | 296.7 | 305.6 |
| | | 8 | ..... | ..... | 297.8 | 309.6 | 323.0 | 338.0 | ..... | ..... | ..... | 298.8 | 309.3 | 321.1 |
| 29 | 25 | 4 | ..... | ..... | ..... | ..... | ..... | 320.6 | | | | | | |
| | | 6 | ..... | ..... | ..... | ..... | 329.1 | 340.6 | ..... | ..... | ..... | ..... | ..... | 327.6 |
| | | 8 | ..... | ..... | ..... | 331.7 | 345.0 | 360.0 | ..... | ..... | ..... | 320.8 | 331.3 | 343.1 |
| 30 | 26 | 6 | ..... | ..... | ..... | ..... | 352.0 | 363.3 | ..... | ..... | ..... | ..... | ..... | 350.6 |
| | | 8 | ..... | ..... | ..... | 354.6 | 368.0 | 383.0 | ..... | ..... | ..... | ..... | 354.3 | 366.0 |

# SQUARE CORED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# JOINT COMMITTEE RECOMMENDATIONS



***2500-lb. concrete***
***1:4½ mixture***
***$n=12$***
***$f_c=565$***

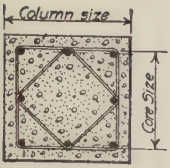
$$P=Af_c[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{side}}\right)=15$$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 8 | 4 | 45.9 | 50.1 | ..... | ..... | ..... | ..... | 43.8 | 47.1 | 51.1 | | | |
| 13 | 9 | 4 | 55.5 | 59.8 | 64.8 | ..... | ..... | ..... | 53.4 | 56.8 | 60.7 | 65.3 | | |
| 14 | 10 | 4 | 66.2 | 70.5 | 75.5 | 81.4 | ..... | ..... | 64.1 | 67.5 | 71.5 | 76.0 | 81.2 | |
| | | 6 | 71.1 | 77.5 | ..... | ..... | ..... | ..... | 67.9 | 73.0 | 78.9 | | | |
| | | 8 | 75.9 | ..... | ..... | ..... | ..... | ..... | 71.8 | 78.5 | | | | |
| 15 | 11 | 4 | 78.1 | 82.4 | 87.4 | 93.2 | ..... | ..... | 76.0 | 79.4 | 83.3 | 87.9 | 93.1 | |
| | | 6 | 82.9 | 89.3 | 96.9 | ..... | ..... | ..... | 79.8 | 84.8 | 90.8 | 97.7 | | |
| | | 8 | 87.8 | 96.3 | ..... | ..... | ..... | ..... | 83.6 | 90.3 | 98.3 | | | |
| 16 | 12 | 4 | 91.1 | 95.3 | 100.4 | 106.2 | 112.8 | ..... | ..... | 92.3 | 96.3 | 100.9 | 106.1 | 111.9 |
| | | 6 | 95.9 | 102.3 | 109.9 | ..... | ..... | ..... | 92.8 | 97.8 | 103.8 | 110.7 | | |
| | | 8 | 100.8 | 129.3 | ..... | ..... | ..... | ..... | 96.6 | 103.3 | 111.3 | | | |
| 17 | 13 | 4 | ..... | 109.5 | 114.5 | 120.4 | 127.0 | 134.3 | ..... | 106.5 | 110.4 | 115.0 | 120.2 | 126.0 |
| | | 6 | 110.1 | 116.5 | 124.0 | 132.8 | ..... | ..... | 106.9 | 112.0 | 117.9 | 124.8 | 132.6 | |
| | | 8 | 114.9 | 123.5 | 133.6 | ..... | ..... | ..... | 110.7 | 117.5 | 125.4 | 134.5 | | |
| 18 | 14 | 4 | ..... | 124.7 | 129.8 | 135.6 | 142.2 | 149.6 | ..... | ..... | 125.7 | 130.3 | 135.5 | 141.3 |
| | | 6 | 125.3 | 131.7 | 139.3 | 148.0 | 157.9 | ..... | ..... | 127.2 | 133.2 | 140.0 | 147.8 | 156.5 |
| | | 8 | 130.2 | 138.7 | 148.8 | ..... | ..... | ..... | 126.0 | 132.7 | 140.6 | 149.8 | | |
| 19 | 15 | 4 | ..... | 141.1 | 146.2 | 152.0 | 158.6 | 166.0 | ..... | ..... | 142.1 | 146.7 | 151.8 | 157.6 |
| | | 6 | 141.7 | 148.1 | 155.7 | 164.4 | 174.3 | ..... | ..... | 143.6 | 149.6 | 156.4 | 164.2 | 172.9 |
| | | 8 | 146.6 | 155.1 | 165.2 | 176.9 | ..... | ..... | 142.4 | 149.1 | 157.0 | 166.2 | 176.6 | |
| 20 | 16 | 4 | ..... | ..... | 163.7 | 169.5 | 176.1 | 183.5 | ..... | ..... | ..... | 164.2 | 169.4 | 175.2 |
| | | 6 | ..... | 165.6 | 173.2 | 181.9 | 191.8 | 202.9 | ..... | 161.1 | 167.1 | 173.9 | 181.7 | 190.4 |
| | | 8 | 164.1 | 172.6 | 182.7 | 194.4 | 207.6 | ..... | ..... | 166.6 | 174.5 | 183.7 | 194.1 | 205.7 |
| 21 | 17 | 4 | ..... | ..... | 182.3 | 188.2 | 194.8 | 202.1 | ..... | ..... | ..... | 182.8 | 188.0 | 193.8 |
| | | 6 | ..... | 184.3 | 191.8 | 200.6 | 210.5 | 221.6 | ..... | ..... | 185.7 | 192.6 | 200.4 | 209.1 |
| | | 8 | 182.7 | 191.3 | 201.4 | 213.0 | 226.2 | ..... | ..... | 185.3 | 193.2 | 202.3 | 212.7 | 224.3 |
| 22 | 18 | 4 | ..... | ..... | ..... | 207.9 | 214.5 | 221.9 | ..... | ..... | ..... | ..... | 207.8 | 213.6 |
| | | 6 | ..... | 204.0 | 211.6 | 220.4 | 230.3 | 241.3 | ..... | ..... | 205.5 | 212.4 | 220.1 | 228.8 |
| | | 8 | ..... | 211.0 | 221.1 | 232.8 | 246.0 | 260.8 | ..... | 205.0 | 213.0 | 222.1 | 232.5 | 244.1 |
| 23 | 19 | 4 | ..... | ..... | ..... | 228.8 | 235.4 | 242.8 | ..... | ..... | ..... | ..... | 228.7 | 234.5 |
| | | 6 | ..... | ..... | 232.5 | 241.3 | 251.2 | 262.2 | ..... | ..... | 226.4 | 233.3 | 241.0 | 249.7 |
| | | 8 | ..... | 231.9 | 242.0 | 253.7 | 266.9 | 281.7 | ..... | ..... | 233.9 | 243.0 | 253.4 | 265.0 |
| 24 | 20 | 4 | ..... | ..... | ..... | 250.9 | 257.5 | 264.8 | ..... | ..... | ..... | ..... | 250.7 | 256.5 |
| | | 6 | ..... | ..... | 254.6 | 263.3 | 273.2 | 284.3 | ..... | ..... | ..... | 255.3 | 263.1 | 271.8 |
| | | 8 | ..... | 254.0 | 264.1 | 275.7 | 288.9 | 303.7 | ..... | ..... | 255.9 | 265.1 | 275.4 | 287.0 |
| 25 | 21 | 4 | ..... | ..... | ..... | ..... | 280.6 | 288.0 | ..... | ..... | ..... | ..... | ..... | 279.7 |
| | | 6 | ..... | ..... | 277.7 | 286.5 | 296.4 | 307.4 | ..... | ..... | ..... | 278.5 | 286.2 | 294.9 |
| | | 8 | ..... | 277.1 | 287.2 | 298.9 | 312.1 | 326.9 | ..... | ..... | 279.1 | 288.2 | 298.6 | 310.2 |
| 26 | 22 | 4 | ..... | ..... | ..... | ..... | 304.9 | 312.3 | ..... | ..... | ..... | ..... | ..... | 304.0 |
| | | 6 | ..... | ..... | ..... | 310.8 | 320.7 | 331.7 | ..... | ..... | ..... | ..... | 310.5 | 319.2 |
| | | 8 | ..... | ..... | 311.5 | 323.2 | 336.4 | 351.2 | ..... | ..... | ..... | 312.5 | 322.9 | 334.5 |
| 27 | 23 | 4 | ..... | ..... | ..... | ..... | ..... | 337.7 | | | | | | |
| | | 6 | ..... | ..... | ..... | 336.2 | 346.1 | 357.2 | ..... | ..... | ..... | ..... | 336.0 | 344.7 |
| | | 8 | ..... | ..... | 337.0 | 348.6 | 361.8 | 376.6 | ..... | ..... | ..... | 337.9 | 348.3 | 359.9 |
| 28 | 24 | 4 | ..... | ..... | ..... | ..... | ..... | 364.3 | | | | | | |
| | | 6 | ..... | ..... | ..... | 362.7 | 372.6 | 383.7 | ..... | ..... | ..... | ..... | 362.5 | 371.2 |
| | | 8 | ..... | ..... | 363.5 | 375.2 | 388.4 | 403.1 | ..... | ..... | ..... | 364.5 | 374.9 | 386.5 |
| 29 | 25 | 4 | ..... | ..... | ..... | ..... | ..... | 392.0 | | | | | | |
| | | 6 | ..... | ..... | ..... | ..... | 400.3 | 411.4 | ..... | ..... | ..... | ..... | ..... | 398.9 |
| | | 8 | ..... | ..... | ..... | 402.9 | 416.1 | 430.8 | ..... | ..... | ..... | 392.2 | 402.6 | 414.1 |
| 30 | 26 | 6 | ..... | ..... | ..... | ..... | 429.1 | 440.2 | ..... | ..... | ..... | ..... | ..... | 427.7 |
| | | 8 | ..... | ..... | ..... | 431.7 | 444.9 | 459.6 | ..... | ..... | ..... | ..... | 431.4 | 443.0 |

**TABLE 23**

**COLUMNS**



## SQUARE CORED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## JOINT COMMITTEE RECOMMENDATIONS

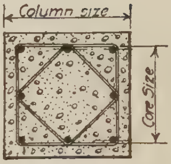
$$P = Af_c[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{side}}\right) = 15$$

*3000-lb. concrete*
*1:3 mixture*
$n = 10$
$f_c = 675$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 12 | 8 | 4 | 52.7 | 56.9 | ..... | ..... | ..... | ..... | 50.7 | 53.9 | 57.8 | | | |
| 13 | 9 | 4 | 64.2 | 68.3 | 73.3 | ..... | ..... | ..... | 62.1 | 65.4 | 69.3 | 73.8 | | |
| 14 | 10 | 4 | 78.0 | 81.2 | 86.1 | 91.8 | ..... | ..... | 75.0 | 78.2 | 82.1 | 86.6 | 91.7 | |
| | | 6 | 81.7 | 86.0 | ..... | ..... | ..... | ..... | 78.7 | 83.6 | 89.4 | | | |
| | | 8 | 86.5 | ..... | ..... | ..... | ..... | ..... | 82.4 | 89.0 | | | | |
| 15 | 11 | 4 | 91.2 | 95.3 | 100.3 | 106.0 | ..... | ..... | 89.1 | 92.4 | 96.3 | 100.8 | 105.7 | |
| | | 6 | 95.9 | 102.2 | 109.6 | ..... | ..... | ..... | 92.9 | 97.8 | 103.6 | 110.3 | | |
| | | 8 | 100.7 | 109.0 | ..... | ..... | ..... | ..... | 96.6 | 103.2 | 110.9 | | | |
| 16 | 12 | 4 | 106.7 | 110.9 | 115.8 | 121.5 | 128.0 | ..... | ..... | 107.9 | 111.8 | 116.3 | 121.4 | 127.0 |
| | | 6 | 111.4 | 117.7 | 125.1 | ..... | ..... | ..... | 108.4 | 113.3 | 119.1 | 125.8 | | |
| | | 8 | 116.2 | 124.5 | ..... | ..... | ..... | ..... | 112.1 | 118.7 | 126.4 | | | |
| 17 | 13 | 4 | ..... | 127.7 | 132.7 | 138.4 | 144.8 | 152.0 | ..... | 124.8 | 128.7 | 133.2 | 138.2 | 143.9 |
| | | 6 | 128.3 | 134.6 | 142.0 | 150.5 | ..... | ..... | 125.3 | 130.2 | 136.0 | 142.7 | 150.3 | |
| | | 8 | 133.1 | 141.4 | 151.3 | ..... | ..... | ..... | 129.0 | 135.6 | 143.3 | 152.3 | | |
| 18 | 14 | 4 | ..... | 146.0 | 150.9 | 156.6 | 163.1 | 170.3 | ..... | ..... | 146.9 | 151.4 | 156.5 | 162.1 |
| | | 6 | 146.5 | 152.8 | 160.2 | 168.8 | 178.4 | ..... | ..... | 148.4 | 154.2 | 160.9 | 168.5 | 177.0 |
| | | 8 | 151.3 | 159.6 | 169.5 | ..... | ..... | ..... | 147.2 | 153.8 | 161.5 | 170.5 | 180.6 | |
| 19 | 15 | 4 | ..... | 165.5 | 170.5 | 176.2 | 182.6 | 189.8 | ..... | ..... | 166.5 | 171.0 | 176.0 | 181.7 |
| | | 6 | 166.1 | 172.4 | 179.8 | 188.3 | 198.0 | ..... | ..... | 168.0 | 173.8 | 180.5 | 188.1 | 196.6 |
| | | 8 | 170.9 | 179.2 | 189.1 | 200.5 | ..... | ..... | 166.8 | 173.4 | 181.1 | 190.1 | 200.2 | |
| 20 | 16 | 4 | ..... | ..... | 191.4 | 197.1 | 203.6 | 210.8 | ..... | ..... | ..... | 191.9 | 197.0 | 202.6 |
| | | 6 | ..... | 193.3 | 200.7 | 209.3 | 218.9 | 229.8 | ..... | 188.9 | 194.7 | 201.4 | 209.0 | 217.5 |
| | | 8 | 191.8 | 200.1 | 210.0 | 221.4 | 234.3 | ..... | ..... | 194.3 | 202.0 | 211.0 | 221.1 | 232.4 |
| 21 | 17 | 4 | ..... | ..... | 213.7 | 219.4 | 225.8 | 233.0 | ..... | ..... | ..... | 214.6 | 219.2 | 224.9 |
| | | 6 | ..... | 215.6 | 223.0 | 231 5 | 241.2 | 252.0 | ..... | ..... | 217.0 | 223.7 | 231.3 | 239.8 |
| | | 8 | 214.1 | 222.4 | 232.3 | 243.7 | 256.6 | ..... | ..... | 216.6 | 224.3 | 233.3 | 243.4 | 254.7 |
| 22 | 18 | 4 | ..... | ..... | ..... | 243.0 | 249.5 | 256.7 | ..... | ..... | ..... | ..... | 242.9 | 248.5 |
| | | 6 | ..... | 239.2 | 246.6 | 255.2 | 261.8 | 275.7 | ..... | ..... | 240.6 | 247.3 | 254.9 | 263.4 |
| | | 8 | ..... | 246.0 | 255.9 | 267.3 | 280.2 | 294.6 | ..... | 240.2 | 247.9 | 256.9 | 267.0 | 278.3 |
| 23 | 19 | 4 | ..... | ..... | ..... | 268.0 | 274.4 | 281.6 | ..... | ..... | ..... | ..... | 267.8 | 273.5 |
| | | 6 | ..... | ..... | 271.6 | 280.1 | 289.8 | 300.6 | ..... | ..... | 265.6 | 272.3 | 279.9 | 288.4 |
| | | 8 | ..... | 271.0 | 280.9 | 292.3 | 305.2 | 319.6 | ..... | ..... | 272.9 | 281.9 | 292.0 | 303.3 |
| 24 | 20 | 4 | ..... | ..... | ..... | 294.3 | 300.8 | 308.0 | ..... | ..... | ..... | ..... | 294.2 | 299 8 |
| | | 6 | ..... | ..... | 297.9 | 306.5 | 316.1 | 327.0 | ..... | ..... | ..... | 298.6 | 306.2 | 314.7 |
| | | 8 | ..... | 297.3 | 307.2 | 318.6 | 331.5 | 345.9 | ..... | ..... | 299.2 | 308.2 | 318.3 | 329.6 |
| 25 | 21 | 4 | ..... | ..... | ..... | ..... | 328.4 | 335.5 | ..... | ..... | ..... | ..... | ..... | 327.5 |
| | | 6 | ..... | ..... | 325.6 | 334.1 | 343.8 | 354.6 | ..... | ..... | ..... | 326.3 | 333.9 | 342.3 |
| | | 8 | ..... | 325.0 | 334.9 | 346.3 | 359.2 | 373.6 | ..... | ..... | 326.9 | 335.9 | 346.0 | 357.3 |
| 26 | 22 | 4 | ..... | ..... | ..... | ..... | 357.5 | 364.7 | ..... | ..... | ..... | ..... | ..... | 356.5 |
| | | 6 | ..... | ..... | ..... | 363.2 | 372.8 | 383.7 | ..... | ..... | ..... | ..... | 362.9 | 371.4 |
| | | 8 | ..... | ..... | 363.9 | 375.3 | 388.2 | 402.6 | ..... | ..... | ..... | 364.9 | 375.0 | 386.3 |
| 27 | 23 | 4 | ..... | ..... | ..... | ..... | ..... | 395.0 | | | | | | |
| | | 6 | ..... | ..... | ..... | 393.5 | 403.2 | 414.0 | ..... | ..... | ..... | ..... | 393.3 | 401.8 |
| | | 8 | ..... | ..... | 394.3 | 405.7 | 418.6 | 433.0 | ..... | ..... | ..... | 395.3 | 405.4 | 416.7 |
| 28 | 24 | 4 | ..... | ..... | ..... | ..... | ..... | 426 8 | | | | | | |
| | | 6 | ..... | ..... | ..... | 425.3 | 434.9 | 445 8 | ..... | ..... | ..... | ..... | 425.0 | 433.5 |
| | | 8 | ..... | ..... | 426.0 | 437.4 | 450.3 | 464.7 | ..... | ..... | ..... | 427.0 | 437.1 | 448.4 |
| 29 | 25 | 4 | ..... | ..... | ..... | ..... | ..... | 459 8 | | | | | | |
| | | 6 | ..... | ..... | ..... | ..... | 468.0 | 478 8 | ..... | ..... | ..... | ..... | ..... | 466.3 |
| | | 8 | ..... | ..... | ..... | 470.5 | 483.4 | 497.8 | ..... | ..... | ..... | 460.1 | 470.2 | 481.5 |
| 30 | 26 | 6 | ..... | ..... | ..... | ..... | 502.4 | 513.3 | ..... | ..... | ..... | ..... | ..... | 501.0 |
| | | 8 | ..... | ..... | ..... | 504.9 | 517.8 | 532.2 | ..... | ..... | ..... | ..... | 504.6 | 515.9 |

# SQUARE CORED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS AND NEW YORK CITY BUILDING CODE REQUIREMENTS



*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 500$

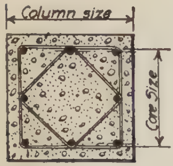
$$P = Af_c[1 + (n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{side}}\right) = 15$$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 8 | 4 | 42.9 | 47.8 | ..... | ..... | ..... | ..... | 40.6 | 44.4 | 48.8 | | | |
| 13 | 9 | 4 | 51.4 | 56.3 | 61.9 | ..... | ..... | ..... | 49.1 | 52.9 | 57.3 | 62.5 | | |
| 14 | 10 | 4 | 60.9 | 65.8 | 71.4 | 78.0 | ..... | ..... | 58.6 | 62.4 | 66.8 | 72.0 | 77.8 | |
| | | 6 | 66.4 | 73.6 | ..... | ..... | ..... | ..... | 62.9 | 68.6 | 75.3 | | | |
| | | 8 | 71.9 | ..... | ..... | ..... | ..... | ..... | 67.2 | 74.7 | | | | |
| 15 | 11 | 4 | 71.4 | 76.3 | 81.9 | 88.5 | ..... | ..... | 69.1 | 72.9 | 77.3 | 82.5 | 88.3 | |
| | | 6 | 76.9 | 84.1 | 92.7 | ..... | ..... | ..... | 73.4 | 79.1 | 85.8 | 93.5 | | |
| | | 8 | 82.4 | 92.0 | ..... | ..... | ..... | ..... | 77.7 | 85.2 | 94.2 | | | |
| 16 | 12 | 4 | 82.9 | 87.8 | 93.4 | 100.0 | 105.4 | ..... | 80.6 | 84.4 | 88.8 | 94.0 | 99.8 | 106.4 |
| | | 6 | 88.4 | 95.6 | 104.2 | ..... | ..... | ..... | 84.9 | 90.6 | 97.3 | 105.0 | | |
| | | 8 | 93.9 | 103.5 | ..... | ..... | ..... | ..... | 89.2 | 96.7 | 105.7 | | | |
| 17 | 13 | 4 | 95.4 | 100.3 | 105.9 | 112.5 | 119.9 | 128.3 | 93.1 | 96.9 | 101.3 | 106.5 | 112.3 | 118.9 |
| | | 6 | 100.9 | 108.1 | 116.7 | 126.5 | ..... | ..... | 97.4 | 103.1 | 109.8 | 117.5 | 126.3 | |
| | | 8 | 106.4 | 116.0 | 127.4 | ..... | ..... | ..... | 101.7 | 109.2 | 118.2 | 128.5 | | |
| 18 | 14 | 4 | 108.9 | 113.8 | 119.4 | 126.0 | 133.4 | 141.8 | 106.6 | 110.4 | 114.8 | 120.0 | 125.8 | 132.4 |
| | | 6 | 114.4 | 121.6 | 130.2 | 140.0 | 151.2 | ..... | 110.9 | 116.6 | 123.3 | 131.0 | 139.8 | 149.5 |
| | | 8 | 119.9 | 129.5 | 140.9 | ..... | ..... | ..... | 115.2 | 122.7 | 131.7 | 142.0 | | |
| 19 | 15 | 4 | 123.4 | 128.3 | 133.9 | 140.5 | 147.9 | 156.3 | 121.1 | 124.9 | 129.3 | 134.5 | 140.3 | 146.9 |
| | | 6 | 128.9 | 136.1 | 144.7 | 154.5 | 165.7 | ..... | 125.4 | 131.1 | 137.8 | 145.5 | 154.3 | 164.0 |
| | | 8 | 134.4 | 144.0 | 155.4 | 168.5 | ..... | ..... | 129.7 | 137.2 | 146.2 | 156.5 | 168.2 | |
| 20 | 16 | 4 | 138.9 | 143.8 | 149.4 | 156.0 | 163.4 | 171.8 | ..... | 140.4 | 144.8 | 150.0 | 155.8 | 162.4 |
| | | 6 | 144.4 | 151.6 | 160.2 | 170.0 | 181.2 | 193.6 | 140.9 | 146.6 | 153.3 | 161.0 | 169.8 | 179.5 |
| | | 8 | 149.9 | 159.5 | 170.9 | 184.0 | 198.9 | ..... | 145.2 | 154.7 | 161.7 | 172.0 | 183.7 | 196.7 |
| 21 | 17 | 4 | 155.4 | 160.3 | 165.9 | 172.5 | 179.9 | 188.3 | ..... | 156.9 | 161.3 | 166.5 | 172.3 | 178.9 |
| | | 6 | 160.9 | 168.1 | 176.7 | 186.5 | 197.7 | 210.1 | 157.4 | 163.1 | 169.8 | 177.5 | 186.3 | 196.0 |
| | | 8 | 166.4 | 176.0 | 187.4 | 200.5 | 215.4 | ..... | 161.7 | 169.2 | 178.2 | 188.5 | 200.2 | 213.2 |
| 22 | 18 | 4 | ..... | 177.8 | 183.4 | 190.0 | 197.4 | 205.8 | ..... | 174.4 | 178.8 | 184.0 | 189.8 | 196.4 |
| | | 6 | 178.4 | 185.6 | 194.2 | 204.0 | 215.2 | 227.6 | 174.9 | 180.6 | 187.3 | 195.0 | 203.8 | 213.5 |
| | | 8 | 183.9 | 193.5 | 204.9 | 218.0 | 232.9 | 249.5 | 179.2 | 186.7 | 195.7 | 206.0 | 217.7 | 230.7 |
| 23 | 19 | 4 | ..... | 196.3 | 201.9 | 208.5 | 215.9 | 224.3 | ..... | ..... | 197.3 | 202.5 | 208.3 | 214.9 |
| | | 6 | 196.9 | 204.1 | 212.7 | 222.5 | 233.7 | 246.1 | 193.4 | 199.1 | 205.8 | 213.5 | 222.3 | 232.0 |
| | | 8 | 202.4 | 212.0 | 223.4 | 236.5 | 251.4 | 268.0 | 197.7 | 205.2 | 214.2 | 224.5 | 236.2 | 249.2 |
| 24 | 20 | 4 | ..... | 215.8 | 221.4 | 228.0 | 235.4 | 243.8 | ..... | ..... | 216.8 | 222.0 | 227.8 | 234.4 |
| | | 6 | 216.4 | 223.6 | 232.2 | 242.0 | 253.2 | 265.6 | ..... | 218.6 | 225.3 | 233.0 | 241.8 | 251.5 |
| | | 8 | 221.9 | 231.5 | 242.9 | 256.0 | 270.9 | 287.5 | 217.2 | 224.7 | 233.7 | 244.0 | 255.7 | 268.7 |
| 25 | 21 | 4 | ..... | 236.3 | 241.9 | 248.5 | 255.9 | 264.3 | ..... | ..... | 237.3 | 242.5 | 248.3 | 254.9 |
| | | 6 | 236.9 | 244.1 | 252.7 | 262.5 | 273.7 | 286.1 | ..... | 239.1 | 245.8 | 253.5 | 262.3 | 272.0 |
| | | 8 | 242.4 | 252.0 | 263.4 | 276.5 | 291.4 | 308.0 | 237.7 | 245.2 | 254.2 | 264.5 | 276.2 | 289.2 |
| 26 | 22 | 4 | ..... | ..... | 263.4 | 270.0 | 277.4 | 285.8 | ..... | ..... | ..... | 264.0 | 269.8 | 276.4 |
| | | 6 | ..... | 265.6 | 274.2 | 284.0 | 295.2 | 307.6 | ..... | 260.6 | 267.3 | 275.0 | 283.8 | 293.5 |
| | | 8 | 263.9 | 273.5 | 284.9 | 298.0 | 312.9 | 329.5 | 259.2 | 266.7 | 275.7 | 286.0 | 297.7 | 310.7 |
| 27 | 23 | 4 | ..... | ..... | 285.9 | 292.5 | 299.9 | 308.3 | ..... | ..... | ..... | 286.5 | 292.3 | 298.9 |
| | | 6 | ..... | 288.1 | 296.7 | 306.5 | 317.7 | 330.1 | ..... | 283.1 | 289.8 | 297.5 | 306.3 | 316.0 |
| | | 8 | 286.4 | 296.0 | 307.4 | 320.5 | 335.4 | 352.0 | 281.7 | 289.2 | 298.2 | 308.5 | 320.2 | 333.2 |
| 28 | 24 | 4 | ..... | ..... | 309.4 | 316.0 | 323.4 | 331.8 | ..... | ..... | ..... | 310.0 | 315.8 | 322.4 |
| | | 6 | ..... | 311.6 | 320.2 | 330.0 | 341.2 | 353.6 | ..... | ..... | 313.3 | 321.0 | 329.8 | 339.5 |
| | | 8 | 309.9 | 319.5 | 330.9 | 344.0 | 358.9 | 375.5 | ..... | 312.7 | 321.7 | 332.0 | 343.7 | 356.7 |
| 29 | 25 | 4 | ..... | ..... | ..... | 340.5 | 347.9 | 356.3 | ..... | ..... | ..... | 334.5 | 340.3 | 346.9 |
| | | 6 | ..... | 336.1 | 344.7 | 354.5 | 365.7 | 378.1 | ..... | ..... | 337.8 | 345.5 | 354.3 | 364.0 |
| | | 8 | 334.4 | 344.0 | 355.4 | 368.5 | 383.4 | 400.0 | ..... | 337.2 | 346.2 | 356.5 | 368.2 | 381.2 |
| 30 | 26 | 4 | ..... | ..... | ..... | 366.0 | 373.4 | 381.8 | ..... | ..... | ..... | ..... | 365.8 | 372.4 |
| | | 6 | ..... | 361.6 | 370.2 | 380.0 | 391.2 | 403.6 | ..... | ..... | 363.3 | 371.0 | 379.8 | 389.5 |
| | | 8 | ..... | 369.5 | 380.9 | 394.0 | 408.9 | 425.5 | ..... | 362.7 | 371.7 | 382.0 | 393.7 | 406.7 |

TABLE 25

# SQUARE CORED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



$$P = Af_c[1+(n-1)p]$$

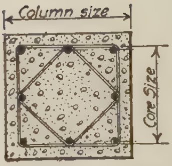
$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{side}}\right) = 15$$

*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 625$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 8 | 4 | 50.7 | 55.5 | ..... | ..... | ..... | ..... | 48.4 | 52.2 | 56.5 | | | |
| 13 | 9 | 4 | 61.4 | 66.1 | 71.7 | ..... | ..... | ..... | 59.1 | 62.8 | 67.2 | 72.2 | | |
| 14 | 10 | 4 | 73.2 | 78.0 | 83.6 | 97.5 | ..... | ..... | 70.9 | 74.7 | 79.0 | 84.1 | 89.8 | |
| | | 6 | 78.6 | 85.7 | ..... | ..... | ..... | ..... | 75.2 | 80.7 | 87.3 | | | |
| | | 8 | 84.0 | ..... | ..... | ..... | ..... | ..... | 79.4 | 86.8 | | | | |
| 15 | 11 | 4 | 86.4 | 91.1 | 96.7 | 103.1 | ..... | ..... | 84.1 | 87.8 | 92.2 | 97.2 | 103.0 | |
| | | 6 | 91.7 | 98.8 | 107.2 | ..... | ..... | ..... | 88.3 | 93.9 | 100.4 | 108.0 | | |
| | | 8 | 97.1 | 106.6 | ..... | ..... | ..... | ..... | 92.5 | 99.9 | 108.7 | | | |
| 16 | 12 | 4 | 100.7 | 105.5 | 111.1 | 117.5 | 124.8 | ..... | 98.4 | 102.2 | 106.5 | 111.6 | 117.3 | 123.8 |
| | | 6 | 106.1 | 113.2 | 121.6 | ..... | ..... | ..... | 102.7 | 108.2 | 114.8 | 122.4 | | |
| | | 8 | 111.5 | 120 9 | ..... | ..... | ..... | ..... | 106.9 | 114.3 | 123.1 | | | |
| 17 | 13 | 4 | 116.4 | 121.1 | 126.7 | 132.1 | 140.4 | 148.6 | 114.1 | 117.8 | 122.2 | 127.2 | 133.0 | 139.4 |
| | | 6 | 121.7 | 128.8 | 137.2 | 146.9 | ..... | ..... | 118.3 | 123.9 | 130.4 | 138.0 | 146.6 | |
| | | 8 | 127.1 | 136.6 | 147.7 | ..... | ..... | ..... | 122.5 | 129.9 | 138.7 | 148.8 | | |
| 18 | 14 | 4 | 133.2 | 138.0 | 143.6 | 150.0 | 157.3 | 165.5 | 130.9 | 134.7 | 139.0 | 144.1 | 149.8 | 156.3 |
| | | 6 | 138.6 | 145.7 | 154.1 | 163.8 | 174.7 | ..... | 135.2 | 140.7 | 147.3 | 154.9 | 163.5 | 173.1 |
| | | 8 | 144.0 | 153.4 | 164.6 | ..... | ..... | ..... | 139.4 | 146.8 | 155.6 | 165.7 | | |
| 19 | 15 | 4 | 151.4 | 156.1 | 161.7 | 168.1 | 175.4 | 183.6 | 149.1 | 152.8 | 157.2 | 162.2 | 168.0 | 174.4 |
| | | 6 | 156.7 | 163.8 | 172.2 | 181.9 | 192.8 | ..... | 153.3 | 158.9 | 165.4 | 173.0 | 181.6 | 191.3 |
| | | 8 | 162.1 | 171.6 | 182.7 | 195.6 | ..... | ..... | 157.5 | 164.9 | 173.7 | 183.8 | 195.3 | |
| 20 | 16 | 4 | 170.7 | 175.5 | 181.1 | 187.5 | 194.8 | 203.0 | ..... | 172.2 | 176.5 | 181.6 | 187.3 | 193.8 |
| | | 6 | 176.1 | 183.2 | 191.6 | 201.3 | 212.2 | 224.5 | 172.7 | 178.2 | 184.8 | 192.4 | 201.0 | 210.6 |
| | | 8 | 181.5 | 190.9 | 202.1 | 215.0 | 229.6 | ..... | 176.9 | 184.3 | 193.1 | 203.2 | 214.7 | 227.5 |
| 21 | 17 | 4 | 191.4 | 196.1 | 201.7 | 208.1 | 215.4 | 223.6 | ..... | 192.8 | 197.2 | 202.2 | 208.0 | 214.4 |
| | | 6 | 196.7 | 203.8 | 212.2 | 221.9 | 232.8 | 245.1 | 193.3 | 198.9 | 205.4 | 213.0 | 221.6 | 231.3 |
| | | 8 | 202.1 | 211.6 | 222.7 | 235.6 | 250.2 | ..... | 197.5 | 204.9 | 213.7 | 223.8 | 235.3 | 248.1 |
| 22 | 18 | 4 | ..... | 218.0 | 223.6 | 230.0 | 237.3 | 245.5 | ..... | 214.7 | 219.0 | 224.1 | 229.8 | 236.3 |
| | | 6 | 218.6 | 225.7 | 234.1 | 243.8 | 254.7 | 267.0 | 215.2 | 220.7 | 227.3 | 234.9 | 243.5 | 253.1 |
| | | 8 | 224.0 | 233.4 | 244.6 | 257.5 | 272.1 | 288.4 | 219.4 | 226.8 | 235.6 | 245.7 | 257.2 | 270.0 |
| 23 | 19 | 4 | ..... | 241.1 | 246.7 | 243.1 | 260.4 | 268.6 | ..... | ..... | 242.2 | 247.2 | 253.0 | 259.4 |
| | | 6 | 241.7 | 248.8 | 257.2 | 266.9 | 277.8 | 290.1 | 238.3 | 243.9 | 250.4 | 258.0 | 266.6 | 276.3 |
| | | 8 | 247.1 | 256.6 | 267.7 | 280.6 | 295.2 | 311.6 | 242.5 | 249.9 | 258.7 | 268.8 | 280.3 | 293.1 |
| 24 | 20 | 4 | ..... | 265.5 | 271.1 | 277.5 | 284.8 | 293.0 | ..... | ..... | 266.5 | 271.6 | 277.3 | 283.8 |
| | | 6 | 266.1 | 273.2 | 281.6 | 291.3 | 302.2 | 314.5 | ..... | 268.2 | 274.8 | 282.4 | 291.0 | 300.6 |
| | | 8 | 271.5 | 280.9 | 292.1 | 305.0 | 319.6 | 335.9 | 266.9 | 274.3 | 283.1 | 293.2 | 304.7 | 317.5 |
| 25 | 21 | 4 | ..... | 291.1 | 296.7 | 303.1 | 310.4 | 318.6 | ..... | ..... | 292.2 | 297.2 | 303.0 | 309.4 |
| | | 6 | 291.7 | 298.8 | 307.2 | 316.9 | 327.8 | 340.1 | ..... | 293.9 | 300.4 | 308.0 | 316.6 | 326.3 |
| | | 8 | 297.1 | 306.6 | 317.7 | 330.6 | 345.2 | 361.6 | 292.5 | 299.9 | 308.7 | 318.8 | 330.3 | 343.1 |
| 26 | 22 | 4 | ..... | ..... | 323.6 | 330.0 | 337.3 | 345.5 | ..... | ..... | ..... | 324.1 | 329.8 | 336.3 |
| | | 6 | ..... | 325.7 | 334.1 | 343.8 | 354.7 | 367.0 | ..... | 320.7 | 327.3 | 334.9 | 343.5 | 353.1 |
| | | 8 | 324.0 | 333.4 | 344.6 | 357.5 | 372.1 | 388.4 | 319.4 | 326.8 | 335.6 | 345.7 | 357.2 | 370.0 |
| 27 | 23 | 4 | ..... | ..... | 351.7 | 358.1 | 365.4 | 373.6 | ..... | ..... | ..... | 352.2 | 358.0 | 364.4 |
| | | 6 | ..... | 353.8 | 362.2 | 371.9 | 382.8 | 395.1 | ..... | 348.9 | 355.4 | 363.0 | 371.6 | 381.3 |
| | | 8 | 352.1 | 361.6 | 372.7 | 385.6 | 400.2 | 416.6 | 347.5 | 354.9 | 363.7 | 373.8 | 385.3 | 398.1 |
| 28 | 24 | 4 | ..... | ..... | 381.1 | 387.5 | 394.8 | 403.0 | ..... | ..... | ..... | 381.6 | 387.3 | 393.8 |
| | | 6 | ..... | 383.2 | 391.6 | 401.3 | 412.2 | 424.5 | ..... | ..... | 384.8 | 392.4 | 401.0 | 410.6 |
| | | 8 | 381.5 | 390.9 | 402.1 | 415.0 | 429.6 | 445.9 | ..... | 384.3 | 393.1 | 403.2 | 414.7 | 427.5 |
| 29 | 25 | 4 | ..... | ..... | ..... | 418.1 | 425.4 | 433.6 | ..... | ..... | ..... | 412.2 | 418.0 | 424.4 |
| | | 6 | ..... | 413.8 | 422.2 | 431.9 | 442.8 | 455.1 | ..... | ..... | 415.4 | 423.0 | 431.6 | 441.3 |
| | | 8 | 412.1 | 421.6 | 432.7 | 445.6 | 460.2 | 476.6 | ..... | 414.9 | 423.7 | 433.8 | 445.3 | 458.1 |
| 30 | 26 | 4 | ..... | ..... | ..... | 450.0 | 457.3 | 465.5 | ..... | ..... | ..... | ..... | 449.8 | 456.3 |
| | | 6 | ..... | 445.7 | 454.1 | 463.8 | 474.7 | 487.0 | ..... | ..... | 447.3 | 454.9 | 463.5 | 473.1 |
| | | 8 | ..... | 453.4 | 464.6 | 477.5 | 492.1 | 508.4 | ..... | 446.8 | 455.6 | 465.7 | 477.2 | 490.0 |

# COLUMNS

## SQUARE CORED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



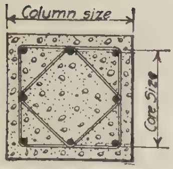
*3000-lb. concrete*
*1:3 mixture*
$n = 12$
$f_c = 750$

$$P = Af_c[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{side}}\right) = 15$$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5/8 | 3/4 | 7/8 | 1 | 1⅛ | 1¼ | 5/8 | 3/4 | 7/8 | 1 | 1⅛ | 1¼ |
| 12 | 8 | 4 | 60.9 | 66.6 | ..... | ..... | ..... | ..... | 58.1 | 62.6 | 67.8 | | | |
| 13 | 9 | 4 | 73.6 | 79.3 | 86.0 | ..... | ..... | ..... | 70.9 | 75.3 | 80.6 | 86.7 | | |
| 14 | 10 | 4 | 87.9 | 93.6 | 100.3 | 108.0 | ..... | ..... | 85.1 | 89.6 | 94.8 | 100.9 | 107.8 | |
| | | 6 | 94.3 | 102.8 | ..... | ..... | ..... | ..... | 90.2 | 96.9 | 104.8 | | | |
| | | 8 | 100.8 | ..... | ..... | ..... | ..... | ..... | 95.3 | 104.2 | | | | |
| 15 | 11 | 4 | 103.6 | 109.3 | 116.0 | 123.8 | ..... | ..... | 100.9 | 105.3 | 110.6 | 116.7 | 123.6 | |
| | | 6 | 110.1 | 118.6 | 128.7 | ..... | ..... | ..... | 105.9 | 112.6 | 120.4 | 129.6 | | |
| | | 8 | 116.5 | 127.9 | ..... | ..... | ..... | ..... | 111.0 | 119.9 | 130.4 | | | |
| 16 | 12 | 4 | 120.9 | 126.6 | 133.3 | 141.0 | 149.8 | ..... | 118.1 | 122.6 | 127.8 | 133.9 | 140.8 | 148.5 |
| | | 6 | 127.3 | 135.8 | 145.9 | ..... | ..... | ..... | 123.2 | 129.9 | 137.8 | 146.9 | | |
| | | 8 | 133.8 | 145.1 | ..... | ..... | ..... | ..... | 128.3 | 137.2 | 147.7 | | | |
| 17 | 13 | 4 | 139.6 | 145.3 | 152.0 | 159.8 | 168.5 | 178.3 | 136.9 | 141.3 | 146.6 | 152.7 | 159.6 | 167.3 |
| | | 6 | 146.1 | 154.6 | 164.7 | 176.3 | ..... | ..... | 141.9 | 148.6 | 156.5 | 165.6 | 176.0 | |
| | | 8 | 152.5 | 163.9 | 177.3 | ..... | ..... | ..... | 147.0 | 155.9 | 166.4 | 177.6 | | |
| 18 | 14 | 4 | 159.9 | 165.6 | 172.3 | 180.0 | 188.8 | 198.6 | 157.1 | 161.6 | 166.8 | 172.9 | 179.8 | 187.5 |
| | | 6 | 166.3 | 174.8 | 184.9 | 196.5 | 209.7 | ..... | 162.2 | 168.9 | 176.8 | 185.9 | 196.1 | 207.7 |
| | | 8 | 172.8 | 184.1 | 197.5 | ..... | ..... | ..... | 167.3 | 176.2 | 186.7 | 198.8 | | |
| 19 | 15 | 4 | 181.6 | 187.3 | 194.0 | 201.8 | 210.5 | 220.3 | 178.9 | 183.3 | 188.6 | 194.7 | 201.6 | 209.3 |
| | | 6 | 188.1 | 196.6 | 206.7 | 218.3 | 231.4 | ..... | 183.9 | 190.6 | 198.4 | 207.6 | 218.0 | 129.5 |
| | | 8 | 194.5 | 205.9 | 219.3 | 234.8 | ..... | ..... | 189.0 | 197.9 | 208.4 | 220.6 | 234.4 | |
| 20 | 16 | 4 | 204.9 | 210.6 | 217.3 | 225.0 | 233.8 | 243.6 | ..... | 206.6 | 211.8 | 217.9 | 224.8 | 232.5 |
| | | 6 | 211.3 | 219.8 | 229.9 | 241.5 | 244.7 | 269.3 | 207.2 | 213.9 | 221.8 | 230.9 | 241.2 | 252.8 |
| | | 8 | 217.8 | 229.1 | 242.5 | 258.0 | 275.5 | ..... | 212.3 | 221.2 | 231.7 | 243.8 | 257.7 | 273.0 |
| 21 | 17 | 4 | 229.6 | 235.3 | 242.0 | 249.8 | 258.5 | 268.3 | ..... | 231.3 | 236.6 | 242.7 | 249.6 | 257.3 |
| | | 6 | 236.1 | 244.6 | 254.7 | 266.3 | 279.4 | 294.1 | 231.9 | 238.6 | 246.5 | 255.6 | 266.0 | 277.5 |
| | | 8 | 242.5 | 253.9 | 267.3 | 282.8 | 300.3 | ..... | 237.0 | 245.9 | 256.4 | 268.6 | 282.4 | 297.8 |
| 22 | 18 | 4 | ..... | 261.6 | 268.3 | 276.0 | 284.8 | 294.6 | ..... | 257.6 | 262.8 | 268.9 | 275.8 | 283.5 |
| | | 6 | 262.3 | 270.8 | 280.9 | 292.5 | 305.7 | 320.3 | 258.2 | 264.9 | 272.8 | 281.9 | 292.2 | 303.8 |
| | | 8 | 268.8 | 280.1 | 293.5 | 309.0 | 326.5 | 346.1 | 263.3 | 272.2 | 282.7 | 294.8 | 308.7 | 324.0 |
| 23 | 19 | 4 | ..... | 289.3 | 296.0 | 303.8 | 312.5 | 322.3 | ..... | ..... | 290.6 | 296.7 | 303.6 | 311.3 |
| | | 6 | 290.1 | 298.6 | 308.7 | 320.3 | 333.4 | 348.1 | 285.9 | 292.6 | 300.5 | 309.6 | 320.0 | 331.5 |
| | | 8 | 296.5 | 307.9 | 321.3 | 336.8 | 354.3 | 373.9 | 291.0 | 299.9 | 310.4 | 322.6 | 336.4 | 351.8 |
| 24 | 20 | 4 | ..... | 318.6 | 325.3 | 333.0 | 341.8 | 351.6 | ..... | ..... | 319.8 | 325.9 | 332.8 | 340.5 |
| | | 6 | 319.3 | 327.8 | 337.9 | 349.5 | 362.7 | 377.3 | ..... | 321.9 | 329.8 | 338.9 | 349.2 | 360.8 |
| | | 8 | 325.8 | 337.1 | 350.5 | 366.0 | 383.5 | 403.1 | 320.3 | 329.2 | 339.7 | 351.8 | 365.7 | 381.0 |
| 25 | 21 | 4 | ..... | 349.3 | 356.0 | 363.8 | 372.5 | 382.3 | ..... | ..... | 350.6 | 356.7 | 363.6 | 371.3 |
| | | 6 | 350.1 | 358.6 | 368.7 | 380.3 | 393.4 | 408.1 | ..... | 352.6 | 360.5 | 369.6 | 380.0 | 391.5 |
| | | 8 | 356.5 | 367.9 | 381.3 | 396.8 | 414.3 | 433.9 | 351.0 | 359.9 | 370.4 | 382.6 | 396.4 | 411.8 |
| 26 | 22 | 4 | ..... | ..... | 388.3 | 396.0 | 404.8 | 414.6 | ..... | ..... | ..... | 388.9 | 395.8 | 403.5 |
| | | 6 | ..... | 390.8 | 400.9 | 412.5 | 425.7 | 440.3 | ..... | 384.9 | 392.8 | 401.9 | 412.2 | 423.8 |
| | | 8 | 388.8 | 400.1 | 413.5 | 429.0 | 446.5 | 466.1 | 383.3 | 392.2 | 402.7 | 414.8 | 428.7 | 444.0 |
| 27 | 23 | 4 | ..... | ..... | 422.0 | 429.8 | 438.5 | 448.3 | ..... | ..... | ..... | 422.7 | 429.6 | 437.3 |
| | | 6 | ..... | 424.6 | 434.7 | 446.3 | 459.4 | 474.1 | ..... | 418.6 | 426.5 | 435.6 | 446.0 | 457.5 |
| | | 8 | 422.5 | 433.9 | 447.3 | 462.8 | 480.3 | 499.9 | 417.0 | 425.9 | 436.4 | 448.6 | 462.4 | 477.8 |
| 28 | 24 | 4 | ..... | ..... | 457.3 | 465.0 | 473.8 | 483.6 | ..... | ..... | ..... | 457.9 | 464.8 | 472.5 |
| | | 6 | ..... | 459.8 | 469.9 | 481.5 | 494.7 | 509.3 | ..... | ..... | 461.8 | 470.9 | 481.2 | 492.8 |
| | | 8 | 457.8 | 469.1 | 482.5 | 498.0 | 515.5 | 535.1 | ..... | 461.2 | 471.7 | 483.8 | 497.7 | 513.0 |
| 29 | 25 | 4 | ..... | ..... | ..... | 501.8 | 510.5 | 520.3 | ..... | ..... | ..... | 494.7 | 501.6 | 509.3 |
| | | 6 | ..... | 496.6 | 506.7 | 518.3 | 531.4 | 546.1 | ..... | ..... | 498.5 | 507.6 | 518.0 | 529.5 |
| | | 8 | 494.5 | 505.9 | 518.3 | 534.8 | 552.3 | 571.9 | ..... | 497.9 | 508.4 | 520.6 | 534.4 | 549.8 |
| 30 | 26 | 4 | ..... | ..... | ..... | 540.0 | 548.8 | 558.6 | ..... | ..... | ..... | ..... | 539.8 | 547.5 |
| | | 6 | ..... | 534.8 | 544.9 | 556.5 | 569.7 | 584.3 | ..... | ..... | 536.8 | 545.9 | 556.2 | 567.8 |
| | | 8 | ..... | 544.1 | 557.5 | 573.0 | 590.5 | 610.1 | ..... | 536.2 | 546.7 | 558.8 | 572.7 | 588.0 |

# SQUARE CORED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# NEW YORK CITY BUILDING CODE REQUIREMENTS



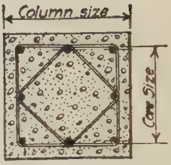
$$P = Af_c[1+(n-1)p]$$

$$Max. \left(\frac{length}{side}\right) = 15$$

*1:4½ mixture*
$n = 12$
$f_c = 600$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods |  |  |  |  |  | Round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 8 | 4 | 48.7 | 53.3 | ..... | ..... | ..... | ..... | 46.5 | 50.1 | 54.3 |  |  |  |
| 13 | 9 | 4 | 58.9 | 63.5 | 68.8 | ..... | ..... | ..... | 56.7 | 60.3 | 64.5 | 69.3 |  |  |
| 14 | 10 | 4 | 70.3 | 54.9 | 80.2 | 86.4 | ..... | ..... | 68.1 | 71.7 | 75.9 | 80.7 | 86.2 |  |
|  |  | 6 | 75.5 | 82.3 | ..... | ..... | ..... | ..... | 72.2 | 77.5 | 83.8 |  |  |  |
|  |  | 8 | 80.6 | ..... | ..... | ..... | ..... | ..... | 76.2 | 83.3 |  |  |  |  |
| 15 | 11 | 4 | 82.9 | 87.5 | 92.8 | 99.0 | ..... | ..... | 80.7 | 84.3 | 88.5 | 93.3 | 98.8 |  |
|  |  | 6 | 88.1 | 94.9 | 102 9 | ..... | ..... | ..... | 84.7 | 90.1 | 96.4 | 103.7 |  |  |
|  |  | 8 | 93.2 | 102.3 | ..... | ..... | ..... | ..... | 88.8 | 95.9 | 104.4 |  |  |  |
| 16 | 12 | 4 | 96.7 | 101.3 | 106.6 | 112.8 | ..... | ..... | 94.5 | 98.1 | 102.3 | 107.1 | 112.6 | 118.8 |
|  |  | 6 | 101.9 | 108.7 | 116.7 | ..... | ..... | ..... | 98.6 | 103.9 | 110.2 | 117.5 |  |  |
|  |  | 8 | 107.0 | 116.1 | ..... | ..... | ..... | ..... | 102.6 | 109.7 | 118.2 |  |  |  |
| 17 | 13 | 4 | 111.7 | 116.3 | 121.6 | 127.8 | 134.8 | 142.7 | 109.5 | 113.1 | 117.3 | 122.1 | 127.6 | 133.8 |
|  |  | 6 | 116.9 | 123.7 | 131.7 | 141.0 | ..... | ..... | 113.6 | 118.9 | 125.2 | 132.5 | 140.8 |  |
|  |  | 8 | 122.0 | 131.1 | 141.8 | ..... | ..... | ..... | 117.6 | 124.7 | 133.2 | 142.9 |  |  |
| 18 | 14 | 4 | 127.9 | 132.5 | 137.8 | 144.0 | 151.0 | 158.9 | 125.7 | 129.3 | 133.5 | 138.3 | 143.8 | 150.0 |
|  |  | 6 | 133.1 | 139.9 | 147.9 | 157.2 | 167.7 | ..... | 129.8 | 135.1 | 141.4 | 148.7 | 157.0 | 166.2 |
|  |  | 8 | 138.2 | 147.3 | 158.0 | ..... | ..... | ..... | 133.8 | 140.9 | 149.4 | 159.1 |  |  |
| 19 | 15 | 4 | 145.3 | 149.9 | 155.2 | 161.4 | 168.4 | 176.3 | 143.1 | 146.7 | 150.9 | 155.7 | 161.2 | 167.4 |
|  |  | 6 | 150.5 | 157.3 | 165.3 | 174.6 | 185.1 | ..... | 147 2 | 152.5 | 158.8 | 166.1 | 174.4 | 183.6 |
|  |  | 8 | 155.6 | 164.7 | 175.4 | 187.8 | ..... | ..... | 151.2 | 158.3 | 166.8 | 176.5 | 187.5 |  |
| 20 | 16 | 4 | 163.9 | 168.5 | 173.8 | 180.0 | 187.0 | 194.9 | ..... | 165.3 | 169.5 | 174.3 | 179.8 | 186.0 |
|  |  | 6 | 169.1 | 175.9 | 183.9 | 193.2 | 203.7 | 215.5 | 165.8 | 171.1 | 177.4 | 184.7 | 193.0 | 202.2 |
|  |  | 8 | 184.2 | 183.3 | 194.0 | 206.4 | 220.4 | ..... | 169.8 | 176.9 | 185.4 | 195.1 | 206.1 | 218.4 |
| 21 | 17 | 4 | 183.7 | 188.3 | 193.6 | 199.8 | 206.8 | 214.7 | ..... | 185.1 | 189.3 | 193.1 | 199.6 | 205.8 |
|  |  | 6 | 188.9 | 195.7 | 203.7 | 213.0 | 223.5 | 235.3 | 185.6 | 190.9 | 197.2 | 204.5 | 212.8 | 222.0 |
|  |  | 8 | 194.0 | 203.1 | 213.8 | 226.2 | 240.2 | 255.9 | 189.6 | 196.7 | 205.2 | 214.9 | 225.9 | 238.2 |
| 22 | 18 | 4 | ..... | 209.3 | 214.6 | 220.8 | 227.8 | 235.7 | ..... | 206.1 | 210.3 | 215.1 | 220.6 | 226.8 |
|  |  | 6 | 209.9 | 216.7 | 224.7 | 234.0 | 244.5 | 256.3 | 206.6 | 212.0 | 218.2 | 225.5 | 233.8 | 243.0 |
|  |  | 8 | 215.0 | 224.1 | 234.8 | 247.2 | 261.2 | 276.9 | 210.6 | 227.7 | 226.2 | 235.9 | 246.9 | 259.2 |
| 23 | 19 | 4 | ..... | 231.5 | 236.8 | 243.0 | 250.0 | 257.9 | ..... | ..... | 232.5 | 237.3 | 242.9 | 249.0 |
|  |  | 6 | 232.1 | 238.9 | 246.9 | 256.2 | 266.7 | 278.5 | 228.8 | 234.1 | 240.4 | 247.7 | 256.0 | 265.2 |
|  |  | 8 | 237.2 | 246.3 | 257.0 | 269.4 | 283.4 | 299.1 | 232.8 | 239.9 | 248.4 | 258.1 | 269.1 | 281.4 |
| 24 | 20 | 4 | ..... | 254.9 | 260.2 | 266.4 | 273.4 | 281.3 | ..... | ..... | 255.9 | 260.7 | 266.2 | 272.4 |
|  |  | 6 | 255.5 | 262.3 | 270.3 | 279.6 | 290.1 | 301.9 | ..... | 257.5 | 263.8 | 271.1 | 279.4 | 288.6 |
|  |  | 8 | 260.6 | 269.7 | 280.4 | 292.8 | 306.8 | 322.5 | 256.2 | 263.3 | 271.8 | 281.5 | 292.5 | 304.8 |
| 25 | 21 | 4 | ..... | 279.5 | 284.8 | 291.0 | 298.0 | 305.9 | ..... | ..... | 280.5 | 285.3 | 290.8 | 297.0 |
|  |  | 6 | 280.1 | 286.9 | 294.9 | 304.2 | 314.7 | 326.5 | ..... | 282.1 | 288.4 | 295.7 | 304.0 | 313.2 |
|  |  | 8 | 285.2 | 294.3 | 305.0 | 317.4 | 331.4 | 347.1 | 280.8 | 287.9 | 296.4 | 306.1 | 347.1 | 329.4 |
| 26 | 22 | 4 | ..... | ..... | 310.6 | 316.8 | 323.8 | 331.7 | ..... | ..... | ..... | 311.1 | 316.6 | 322.8 |
|  |  | 6 | ..... | 312.7 | 320.7 | 330.0 | 340.5 | 352.3 | ..... | 307.9 | 314.2 | 321.5 | 329.8 | 339.0 |
|  |  | 8 | 311.0 | 320.1 | 330.8 | 343.0 | 357.2 | 372.9 | 306.6 | 313.7 | 322.2 | 331.9 | 342.9 | 355.2 |
| 27 | 23 | 4 | ..... | ..... | 337.6 | 343.8 | 350.8 | 358.7 | ..... | ..... | ..... | 338.1 | 343.6 | 349.8 |
|  |  | 6 | ..... | 339.7 | 347.7 | 357.0 | 367.4 | 379.3 | ..... | 334.9 | 341.2 | 348.5 | 356.8 | 366.0 |
|  |  | 8 | 338.0 | 347.1 | 357.8 | 370.2 | 384.2 | 399.9 | 333.6 | 340.7 | 349.2 | 358.9 | 369.5 | 372.2 |
| 28 | 24 | 4 | ..... | ..... | 365.8 | 372.0 | 379.0 | 386.9 | ..... | ..... | ..... | 366.3 | 371.8 | 378.0 |
|  |  | 6 | ..... | 367.9 | 375.9 | 385.2 | 395.7 | 407.5 | ..... | ..... | 369.4 | 376.7 | 385.0 | 394.2 |
|  |  | 8 | 366.2 | 375.3 | 386.0 | 398.4 | 412.4 | 428.1 | 361.8 | 368.9 | 377.4 | 387.1 | 398.1 | 410.4 |
| 29 | 25 | 4 | ..... | ..... | ..... | 401.4 | 408.4 | 416.3 | ..... | ..... | ..... | 395.7 | 401.2 | 407.4 |
|  |  | 6 | ..... | 397.3 | 405.3 | 414.6 | 425.1 | 436.9 | ..... | ..... | 398.8 | 406.1 | 414.4 | 423.6 |
|  |  | 8 | 395.6 | 404.7 | 415.4 | 427.8 | 441.8 | 457.5 | ..... | 398.3 | 406.8 | 416.5 | 427.5 | 439.8 |
| 30 | 26 | 4 | ..... | ..... | ..... | 432.0 | 439.0 | 447.3 | ..... | ..... | ..... | ..... | 431.8 | 438.0 |
|  |  | 6 | ..... | 427.9 | 435.9 | 445.2 | 455.7 | 467.9 | ..... | ..... | 429.4 | 436.7 | 445.0 | 454.2 |
|  |  | 8 | ..... | 435.3 | 446.0 | 458.4 | 472.4 | 488.5 | ..... | 428.9 | 437.4 | 447.1 | 458.1 | 470.4 |

# SQUARE CORED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS



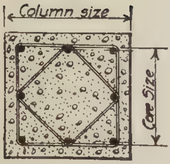
*2000-lb. concrete*
*1: 6 mixture*
$n = 15$
$f_c = 400$

$$P = Af_c[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{side}}\right) = 12$$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 12 | 9 | 4 | 41.2 | 45.0 | ..... | ..... | ..... | ..... | 39.3 | 42.3 | 45.9 | | | |
| 13 | 10 | 4 | 48.8 | 52.6 | ..... | ..... | ..... | ..... | 46.9 | 49.9 | 53.5 | | | |
| 14 | 11 | 4 | 57.2 | 61.0 | 65.6 | ..... | ..... | ..... | 55.3 | 57.3 | 61.9 | 66.0 | | |
| | | 6 | 61.5 | 67.3 | ..... | ..... | ..... | ..... | 58.7 | 63.2 | 68.6 | | | |
| | | 8 | 65.9 | ..... | ..... | ..... | ..... | ..... | 62.2 | 68.2 | | | | |
| 15 | 12 | 4 | 66.4 | 70.2 | 74.8 | 80.0 | ..... | ..... | 64.5 | 67.5 | 71.1 | 75.2 | 79.9 | |
| | | 6 | 70.7 | 76.5 | ..... | ..... | ..... | ..... | 67.9 | 72.4 | 77.8 | | | |
| | | 8 | 75.1 | ..... | ..... | ..... | ..... | ..... | 71.4 | 77.4 | | | | |
| 16 | 13 | 4 | 76.4 | 80.2 | 84.8 | 90.0 | 96.0 | ..... | 74.5 | 77.5 | 81.1 | 85.2 | 89.9 | 95.1 |
| | | 6 | 80.7 | 86.5 | 93.3 | ..... | ..... | ..... | 77.9 | 82.4 | 87.8 | 94.0 | | |
| | | 8 | 85.1 | 92.8 | ..... | ..... | ..... | ..... | 81.4 | 87.4 | 94.5 | | | |
| 17 | 14 | 4 | 87.2 | 91.0 | 95.6 | 100.8 | 106.8 | ..... | 85.3 | 88.3 | 91.9 | 96.0 | 100.7 | 105.9 |
| | | 6 | 91.5 | 97.3 | 104.1 | ..... | ..... | ..... | 88.7 | 93.2 | 98.6 | 104.8 | | |
| | | 8 | 95.9 | 103.6 | ..... | ..... | ..... | ..... | 92.2 | 98.2 | 105.3 | | | |
| 18 | 15 | 4 | 99.8 | 102.6 | 107.2 | 112.4 | 118.4 | 125.0 | 96.9 | 99.9 | 103.5 | 107.6 | 112.3 | 117.5 |
| | | 6 | 103.1 | 108.9 | 115.7 | 123.6 | ..... | ..... | 100.3 | 104.8 | 110.2 | 116.4 | 123.4 | |
| | | 8 | 107.5 | 115.2 | 124.3 | ..... | ..... | ..... | 103.8 | 109.8 | 116.9 | 125.2 | | |
| 19 | 16 | 4 | 111.2 | 115.0 | 119.6 | 124.8 | 130.8 | 137.4 | ..... | 112.3 | 115.9 | 120.0 | 124.7 | 129.9 |
| | | 6 | 115.5 | 121.3 | 128.1 | 136.0 | 144.9 | .... | 112.7 | 117.2 | 122.6 | 128.8 | 135.8 | 143.6 |
| | | 8 | 119.9 | 127.6 | 136.7 | ..... | ..... | ..... | 116.2 | 122.2 | 129.3 | 137.6 | | |
| 20 | 17 | 4 | 124.4 | 128.2 | 132.8 | 138.0 | 144.0 | 150.6 | ..... | 125.5 | 129.1 | 133.2 | 137.9 | 143.1 |
| | | 6 | 128.7 | 134.5 | 141.3 | 149.2 | 158.1 | ..... | 125.9 | 130.4 | 135.8 | 142.0 | 149.0 | 156.8 |
| | | 8 | 133.1 | 140.8 | 149.9 | 160.4 | ..... | ..... | 129.4 | 135.4 | 142.5 | 150.8 | 160.1 | |
| 21 | 18 | 4 | ..... | 142.2 | 146.8 | 152.0 | 158.0 | 164.6 | ..... | 139.5 | 143.1 | 149.2 | 151.9 | 157.1 |
| | | 6 | 142.7 | 148.5 | 155.3 | 163.2 | 172.1 | 182.1 | 139.9 | 144.4 | 149.8 | 156.0 | 163.0 | 170.8 |
| | | 8 | 147.1 | 154.8 | 163.9 | 174.4 | ..... | ..... | 143.4 | 149.4 | 156.5 | 164.8 | 174.1 | |
| 22 | 19 | 4 | ..... | 157.0 | 161.6 | 166.8 | 172.8 | 179.4 | ..... | ..... | 157.9 | 162.0 | 166.7 | 171.9 |
| | | 6 | 157.5 | 163.3 | 170.1 | 178.0 | 186.9 | 196.9 | 154.7 | 159.2 | 164.6 | 170.8 | 177.8 | 185.6 |
| | | 8 | 161.9 | 169.6 | 178.7 | 189 2 | 201.1 | ..... | 158.2 | 164.2 | 171.3 | 179.6 | 188.9 | 199.4 |
| 23 | 20 | 4 | ..... | 172.6 | 177.2 | 182.4 | 188.4 | 195.0 | ..... | ..... | 173.5 | 177.6 | 182.3 | 187.5 |
| | | 6 | 173.1 | 178.9 | 185.7 | 193.6 | 202.5 | 212.5 | ..... | 174.8 | 180.2 | 186.4 | 193.4 | 201.2 |
| | | 8 | 177.5 | 185.2 | 194.3 | 204.8 | 216.7 | ..... | 173.8 | 179.8 | 186.9 | 195.2 | 204.5 | 215.0 |
| 24 | 21 | 4 | ..... | 189.0 | 193.6 | 198.8 | 204.8 | 211.4 | ..... | ..... | 189.9 | 194.0 | 198.7 | 203.9 |
| | | 6 | 189.5 | 195.3 | 202.1 | 210.0 | 218.9 | 228.9 | ... | 191.2 | 196.6 | 202.8 | 209.8 | 217.6 |
| | | 8 | 193.9 | 201.6 | 210.7 | 221.2 | 233.1 | 246.4 | 190.2 | 196.2 | 203.3 | 211.6 | 220.9 | 231.4 |
| 25 | 22 | 4 | ..... | ..... | 210.8 | 216.0 | 222.0 | 228.6 | ..... | ..... | ..... | 211.2 | 215.9 | 221.1 |
| | | 6 | ..... | 212.5 | 219.3 | 227.2 | 236.1 | 246.1 | .... | 208.4 | 213.8 | 220.0 | 227.0 | 234.8 |
| | | 8 | 211.1 | 218.8 | 227.9 | 238.4 | 250.3 | 263.6 | 207.4 | 213 4 | 220.5 | 228.8 | 238.1 | 248.6 |
| 26 | 23 | 4 | ..... | ..... | 228.8 | 234.0 | 240.0 | 246.6 | ..... | ..... | ..... | 229.2 | 233.9 | 239.1 |
| | | 6 | ..... | 230.5 | 237.3 | 245.2 | 254.1 | 264.1 | ..... | 226.4 | 231.8 | 238.0 | 245.0 | 252.8 |
| | | 8 | 229.1 | 236.8 | 245.9 | 256.4 | 268.3 | 281.6 | ..... | 231.4 | 238.5 | 246.8 | 256.1 | 266.6 |
| 27 | 24 | 4 | ..... | ..... | 247.6 | 252.8 | 258.8 | 265.4 | ..... | ..... | ..... | 248.0 | 252.7 | 257.9 |
| | | 6 | ..... | 249.3 | 256.1 | 264.0 | 272.9 | 282.9 | ..... | ..... | 250.6 | 256.8 | 263.8 | 271.6 |
| | | 8 | 247.9 | 255.6 | 264.7 | 275.2 | 287.1 | 300.4 | ..... | 250.2 | 257.3 | 265.6 | 274.9 | 285.4 |
| 28 | 25 | 4 | ..... | ..... | ..... | 272.4 | 278.4 | 285.0 | ..... | ..... | ..... | 267.6 | 272.3 | 277.5 |
| | | 6 | ..... | 268.9 | 275.7 | 283.6 | 292.5 | 302.5 | ..... | ..... | 270.2 | 276.4 | 283.4 | 291.2 |
| | | 8 | 267.5 | 275.2 | 284.3 | 294.8 | 306.7 | 320.0 | ..... | 269.8 | 276.9 | 285.2 | 294.5 | 305.0 |
| 29 | 26 | 4 | ..... | ..... | ..... | 292.8 | 298.8 | 305.4 | ..... | ..... | ..... | ..... | 292.7 | 297.9 |
| | | 6 | ..... | 289.3 | 296.1 | 304.0 | 312.9 | 322.9 | ..... | ..... | 290.6 | 296.8 | 303.8 | 311.6 |
| | | 8 | ..... | 295.6 | 304.7 | 315.2 | 327.1 | 340.4 | ..... | 290.2 | 297.3 | 305.6 | 314.9 | 325.4 |
| 30 | 27 | 4 | ..... | ..... | ..... | 292.8 | 298.8 | 305.4 | ..... | ..... | ..... | ..... | 292.7 | 297.9 |
| | | 6 | ..... | ..... | 296.1 | 304.0 | 312.9 | 322.9 | ..... | ..... | ..... | 296.8 | 303.8 | 311.6 |
| | | 8 | ..... | 295.6 | 304.7 | 315.2 | 327.1 | 340.4 | ..... | ..... | 297.3 | 305.6 | 314.9 | 325.4 |

**TABLE 29**



# SQUARE CORED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

$$P = Af_c[1+(n-1)p]$$

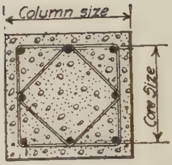
$$\text{Max.}\left(\frac{\text{length}}{\text{side}}\right) = 12$$

*2400-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 480$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 9 | 4 | 47.1 | 50.8 | ..... | ..... | ..... | ..... | 45.4 | 48.2 | 51.0 | | | |
| 13 | 10 | 4 | 56.3 | 59.9 | ..... | ..... | ..... | ..... | 54.5 | 57.3 | 60.7 | | | |
| 14 | 11 | 4 | 66.3 | 69.0 | 74.3 | ..... | ..... | ..... | 64.6 | 67.4 | 70.8 | 74.7 | | |
| | | 6 | 70.5 | 75.9 | ..... | ..... | ..... | ..... | 67.8 | 72.1 | 77.1 | | | |
| | | 8 | 74.6 | ..... | ..... | ..... | ..... | ..... | 71.0 | 76.7 | | | | |
| 15 | 12 | 4 | 77.4 | 81.0 | 85.3 | 90.2 | ..... | ..... | 75.6 | 78.5 | 81.8 | 85.7 | 90.1 | |
| | | 6 | 81.5 | 86.9 | ..... | ..... | ..... | ..... | 78.8 | 83.1 | 88.2 | | | |
| | | 8 | 85.6 | ..... | ..... | ..... | ..... | ..... | 82.1 | 87.8 | | | | |
| 16 | 13 | 4 | 89.4 | 93.0 | 97.3 | 102.2 | 107.9 | ..... | 87.6 | 90.5 | 93.8 | 97.7 | 102.1 | 107.0 |
| | | 6 | 93.5 | 98.9 | 105.4 | ..... | ..... | ..... | 90.8 | 95.1 | 100.2 | 106.0 | | |
| | | 8 | 97.6 | 104.9 | ..... | ..... | ..... | ..... | 94.1 | 99.8 | 106.5 | | | |
| 17 | 14 | 4 | 102.3 | 106.0 | 110.3 | 115.2 | 120.8 | ..... | 100.6 | 103.4 | 106.8 | 110.7 | 115.1 | 120.0 |
| | | 6 | 106.5 | 111.9 | 118.3 | ..... | ..... | ..... | 103.8 | 108.1 | 113.1 | 119.0 | | |
| | | 8 | 110.6 | 117.8 | ..... | ..... | ..... | ..... | 107.0 | 112.7 | 119.5 | | | |
| 18 | 15 | 4 | 116.3 | 119.9 | 124.2 | 129.1 | 134.7 | 141.0 | 114.5 | 117.3 | 120.7 | 124.6 | 129.0 | 133.9 |
| | | 6 | 120.4 | 125.8 | 132.3 | 139.7 | ..... | ..... | 117.7 | 122.0 | 127.1 | 132.9 | 139.5 | |
| | | 8 | 124.5 | 131.8 | 140.3 | ..... | ..... | ..... | 121.0 | 126.7 | 133.4 | 141.2 | | |
| 19 | 16 | 4 | 131.1 | 134.8 | 139.1 | 144.0 | 149.6 | 155.9 | ..... | 132.2 | 135.6 | 139.5 | 143.9 | 148.8 |
| | | 6 | 135.3 | 140.7 | 147.1 | 154.6 | 163.0 | ..... | 132.6 | 136.9 | 141.9 | 147.8 | 154.4 | 161.8 |
| | | 8 | 139.4 | 146.6 | 155.2 | ..... | ..... | ..... | 135.8 | 141.5 | 148.3 | 156.1 | | |
| 20 | 17 | 4 | 147.0 | 150.6 | 154.9 | 159.8 | 165.5 | 171.7 | .... | 148.1 | 151.4 | 155.3 | 159.7 | 164.6 |
| | | 6 | 151.1 | 156.5 | 163.0 | 170.4 | 178.8 | ..... | 148.4 | 152.7 | 157.8 | 163.6 | 170.2 | 177.6 |
| | | 8 | 155.2 | 162.5 | 171.1 | 181.0 | ..... | ..... | 151.7 | 157.4 | 164.1 | 171.9 | 180.7 | |
| 21 | 18 | 4 | ..... | 167.4 | 171.7 | 176.6 | 182.3 | 188.5 | ..... | 164.9 | 168.2 | 172.1 | 176.5 | 181.4 |
| | | 6 | 167.9 | 173.3 | 179.8 | 187.2 | 195.6 | 205.0 | 165.2 | 169.5 | 174.6 | 180.4 | 187.0 | 194.4 |
| | | 8 | 172.0 | 179.3 | 187.9 | 197.8 | ..... | ..... | 168.5 | 174.2 | 180.9 | 188.7 | 197.5 | |
| 22 | 19 | 4 | ..... | 185.2 | 189.5 | 194.4 | 200.0 | 206.3 | ..... | ..... | 186.0 | 189.9 | 194.3 | 199.2 |
| | | 6 | 185.7 | 191.1 | 197.5 | 205.0 | 213.4 | 222.8 | 183.0 | 187.3 | 192.3 | 198.2 | 204.8 | 212.2 |
| | | 8 | 189.8 | 197.0 | 205.6 | 215.5 | 226.7 | ..... | 186.2 | 191.9 | 198.7 | 206.5 | 215.3 | 225.1 |
| 23 | 20 | 4 | ..... | 203.9 | 208.2 | 213.1 | 218.7 | 225.0 | ..... | ..... | 204.7 | 208.6 | 213.0 | 217.9 |
| | | 6 | 204.4 | 209.8 | 216.3 | 223.7 | 232.1 | 241.5 | ..... | 206.0 | 211.1 | 216.9 | 223.5 | 230.9 |
| | | 8 | 208.5 | 215.8 | 224.3 | 234.2 | 245.5 | ..... | 205.0 | 210.7 | 217.4 | 225.2 | 234.0 | 243.8 |
| 24 | 21 | 4 | ..... | 223.6 | 227.9 | 232.8 | 238.4 | 244.7 | ..... | ..... | 224.4 | 228.3 | 232.7 | 237.6 |
| | | 6 | 224.1 | 229.5 | 235.9 | 243.4 | 251.8 | 261.2 | ..... | 225.7 | 230.7 | 236.6 | 243.2 | 250.6 |
| | | 8 | 228.2 | 235.4 | 244.0 | 253.9 | 265.1 | 277.7 | 224.6 | 230.3 | 237.1 | 244.9 | 253.7 | 263.5 |
| 25 | 22 | 4 | ..... | ..... | 248.5 | 253.4 | 259.1 | 265.3 | ..... | ..... | ..... | 248.9 | 253.3 | 258.2 |
| | | 6 | ..... | 250.1 | 256.6 | 264.0 | 272.4 | 281.8 | ..... | 246.3 | 251.4 | 257.2 | 263.8 | 271.2 |
| | | 8 | 248.8 | 256.1 | 264.7 | 274.6 | 285.8 | 298.3 | 245.3 | 251.0 | 257.7 | 265.5 | 274.3 | 284.2 |
| 26 | 23 | 4 | ..... | ..... | 270.1 | 275.0 | 280.7 | 286.9 | ... | ..... | ..... | 270.5 | 274.9 | 278.8 |
| | | 6 | ..... | 271.7 | 278.2 | 285.6 | 294.0 | 303.4 | ..... | 267.9 | 273.0 | 278.8 | 285.4 | 292.8 |
| | | 8 | 270.4 | 277.7 | 286.3 | 296.2 | 307.4 | 319.9 | ..... | 272.6 | 279.3 | 287.1 | 295.9 | 305.8 |
| 27 | 24 | 4 | ..... | ..... | 292.7 | 297.6 | 303.2 | 309.5 | ..... | ..... | ..... | 283.1 | 297.5 | 302.4 |
| | | 6 | ..... | 294.3 | 300.7 | 308.2 | 316.6 | 326.0 | ..... | ..... | 295.5 | 301.4 | 308.0 | 315.4 |
| | | 8 | 293.0 | 300.2 | 308.8 | 318.7 | 329.9 | 342.5 | ..... | 295.1 | 301.9 | 309.7 | 318.5 | 328.3 |
| 28 | 25 | 4 | ..... | ..... | ..... | 321.1 | 326.7 | 333.0 | ..... | ..... | ..... | 316.6 | 321.0 | 325.9 |
| | | 6 | ..... | 317.8 | 324.3 | 331.7 | 340.1 | 349.5 | ..... | ..... | 319.1 | 324.9 | 331.5 | 338.9 |
| | | 8 | 316.5 | 323.8 | 332.3 | 342.2 | 353.5 | 366.0 | ..... | 318.7 | 325.4 | 333.2 | 342.0 | 351.8 |
| 29 | 26 | 4 | ..... | ..... | ..... | 345.6 | 351.2 | 357.5 | ..... | ..... | ..... | ..... | 345.5 | 350.4 |
| | | 6 | ..... | 342.3 | 348.7 | 356.2 | 364.6 | 374.0 | ..... | ..... | 343.5 | 349.4 | 356.0 | 363.4 |
| | | 8 | ..... | 348.2 | 356.8 | 366.7 | 377.9 | 390.5 | ..... | 343.1 | 349.9 | 357.7 | 366.5 | 376.3 |
| 30 | 27 | 4 | ..... | ..... | ..... | 371.0 | 376.7 | 382.9 | ..... | ..... | ..... | ..... | 370.9 | 375.8 |
| | | 6 | ..... | ..... | 374.2 | 381.6 | 390.0 | 399.4 | ..... | ..... | ..... | 374.8 | 381.4 | 388.8 |
| | | 8 | ..... | 373.7 | 382.3 | 392.2 | 403.4 | 415.9 | ..... | ..... | 375.3 | 383.1 | 391.9 | 401.8 |

TABLE 30

# SQUARE CORED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

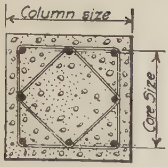


*2900-lb. concrete*
*1:3 mixture*
$n=10$
$f_c=580$

$$P = Af_c[1+(n-1)p]$$

$$\text{Max.}\left(\frac{length}{side}\right) = 12$$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 9 | 4 | 55.1 | 58.7 | ..... | ..... | ..... | ..... | 53.4 | 56.2 | 59.5 | | | |
| 13 | 10 | 4 | 66.2 | 69.8 | ..... | ..... | ..... | ..... | 64.4 | 67.2 | 70.6 | | | |
| 14 | 11 | 4 | 78.3 | 81.9 | 86.2 | ..... | ..... | ..... | 76.6 | 79.4 | 82.7 | 86.6 | | |
| | | 6 | 82.4 | 87.8 | ..... | ..... | ..... | ..... | 79.8 | 84.0 | 89.0 | | | |
| | | 8 | 86.5 | ..... | ..... | ..... | ..... | ..... | 83.0 | 88.6 | | | | |
| 15 | 12 | 4 | 91.7 | 95.3 | 99.5 | 104.4 | ..... | ..... | 89.9 | 92.8 | 96.1 | 99.9 | 104.3 | |
| | | 6 | 95.7 | 101.1 | ..... | ..... | ..... | ..... | 93.1 | 97.4 | 102.4 | | | |
| | | 8 | 99.8 | ..... | ..... | ..... | ..... | ..... | 96.3 | 102.0 | | | | |
| 16 | 13 | 4 | 106.2 | 109.8 | 114.0 | 118.9 | 124.5 | ..... | 104.4 | 107.3 | 110.6 | 114.4 | 118.8 | 123.6 |
| | | 6 | 110.2 | 115.6 | 122.0 | ..... | ..... | ..... | 107.6 | 111.9 | 116.9 | 122.6 | | |
| | | 8 | 114.3 | 121.5 | ..... | ..... | ..... | ..... | 110.8 | 116.5 | 123.1 | | | |
| 17 | 14 | 4 | 121.8 | 125.4 | 129.7 | 134.6 | 140.1 | ..... | 120.1 | 122.9 | 126.2 | 130.1 | 134.4 | 139.3 |
| | | 6 | 125.9 | 131.3 | 137.7 | ..... | ..... | ..... | 123.3 | 127.5 | 132.5 | 138.3 | | |
| | | 8 | 130.0 | 137.2 | ..... | ..... | ..... | ..... | 126.5 | 132.1 | 138.8 | | | |
| 18 | 15 | 4 | 138.7 | 142.3 | 146.5 | 151.4 | 156.9 | 163.1 | 136.9 | 139.7 | 143.1 | 146.9 | 151.3 | 156.1 |
| | | 6 | 142.7 | 148.1 | 154.5 | 161.8 | ..... | ..... | 140.1 | 144.3 | 149.3 | 155.1 | 161.6 | |
| | | 8 | 146.8 | 154.0 | 162.5 | ..... | ..... | ..... | 143.3 | 149.0 | 155.6 | 163.3 | | |
| 19 | 16 | 4 | 156.6 | 160.2 | 164.5 | 169.4 | 174.9 | 181.1 | ..... | 157.7 | 161.0 | 164.9 | 169.2 | 174.1 |
| | | 6 | 160.7 | 166.1 | 172.5 | 179.8 | 188.1 | ..... | 158.1 | 162.3 | 167.3 | 173.1 | 179.6 | 186.9 |
| | | 8 | 164.8 | 172.0 | 180.5 | ..... | ..... | ..... | 161.3 | 166.9 | 173.6 | 181.3 | | |
| 20 | 17 | 4 | 175.8 | 179.4 | 183.6 | 188.5 | 194.1 | 200.3 | ..... | 176.9 | 180.2 | 184.0 | 188.4 | 193.2 |
| | | 6 | 179.8 | 185.2 | 191.6 | 198.9 | 207.3 | ..... | 177.2 | 181.5 | 186.5 | 192.2 | 198.8 | 206.1 |
| | | 8 | 183.9 | 191.1 | 199.6 | 209.4 | ..... | ..... | 180.4 | 186.1 | 192.7 | 200.4 | 209.2 | |
| 21 | 18 | 4 | ..... | 199.7 | 203.9 | 208.8 | 214.4 | 220.6 | ..... | 197.2 | 200.5 | 204.3 | 208.7 | 213.5 |
| | | 6 | 200.1 | 205.5 | 211.9 | 219.2 | 227.6 | 236.9 | 197.5 | 201.8 | 206.8 | 212.5 | 219.1 | 226.4 |
| | | 8 | 204.2 | 211.4 | 219.9 | 229.7 | ..... | ..... | 200.7 | 206.4 | 213.0 | 220.7 | 229.5 | |
| 22 | 19 | 4 | ..... | 221.1 | 225.4 | 230.3 | 235.8 | 242.0 | ..... | ..... | 221.9 | 225.8 | 230.1 | 235.0 |
| | | 6 | 221.6 | 227.0 | 233.4 | 240.7 | 249.0 | 258.3 | 219.0 | 223.2 | 228.2 | 234.0 | 240.5 | 247.8 |
| | | 8 | 225.7 | 232.9 | 241.4 | 251.1 | 262.2 | ..... | 222.2 | 227.8 | 234.5 | 242.2 | 251.0 | 260.6 |
| 23 | 20 | 4 | ..... | 243.8 | 248.0 | 252.9 | 258.4 | 264.6 | ..... | ..... | 244.6 | 248.4 | 252.8 | 257.6 |
| | | 6 | 244.2 | 249.6 | 256.0 | 263.3 | 271.6 | 280.9 | ..... | 245.8 | 250.8 | 256.6 | 263.1 | 270.4 |
| | | 8 | 248.3 | 255.5 | 264.0 | 273.8 | 284.9 | ..... | 244.8 | 250.5 | 257.1 | 264.8 | 273.6 | 283.3 |
| 24 | 21 | 4 | ..... | 267.5 | 271.8 | 276.7 | 282.2 | 288.4 | ..... | ..... | 268.3 | 272.2 | 276.5 | 281.4 |
| | | 6 | 268.0 | 273.4 | 279.8 | 287.1 | 295.4 | 304.7 | ..... | 269.6 | 274.6 | 280.4 | 286.9 | 294.2 |
| | | 8 | 272.1 | 279.3 | 287.8 | 297.5 | 308.6 | 321.0 | 268.6 | 274.2 | 280.9 | 288.6 | 297.4 | 307.0 |
| 25 | 22 | 4 | ..... | ..... | 296.7 | 301.6 | 307.2 | 313.4 | ..... | ..... | ..... | 297.1 | 301.5 | 306.3 |
| | | 6 | ..... | 298.3 | 304.7 | 312.0 | 320.4 | 329.7 | ..... | 294.6 | 299.6 | 305.3 | 311.9 | 319.2 |
| | | 8 | 297.0 | 304.2 | 312.7 | 322.5 | 333.6 | 346.0 | 293.5 | 299.2 | 305.8 | 313.5 | 322.3 | 332.0 |
| 26 | 23 | 4 | ..... | ..... | 322.8 | 327.7 | 333.3 | 339.5 | ..... | ..... | ..... | 323.2 | 327.6 | 332.4 |
| | | 6 | ..... | 324.4 | 330.8 | 338.1 | 346.5 | 355.9 | ..... | 320.7 | 325.7 | 331.4 | 338.0 | 345.3 |
| | | 8 | 323.1 | 330.3 | 337.9 | 348.6 | 359.7 | 372.1 | ..... | 325.3 | 831.9 | 339.6 | 348.4 | 358.1 |
| 27 | 24 | 4 | ..... | ..... | 350.1 | 355.0 | 360.5 | 366.7 | ..... | ..... | ..... | 350.5 | 354.8 | 359.7 |
| | | 6 | ..... | 351.7 | 358.1 | 365.4 | 373.7 | 383.0 | ..... | ..... | 352.9 | 358.7 | 365.2 | 372.5 |
| | | 8 | 350.4 | 357.6 | 366.1 | 375.8 | 386.9 | 399.3 | ..... | 352.5 | 359.2 | 366.9 | 375.7 | 385.3 |
| 28 | 25 | 4 | ..... | ..... | ..... | 383.4 | 388.9 | 395.1 | ..... | ..... | ..... | 378.9 | 383.3 | 388.1 |
| | | 6 | ..... | 380.1 | 386.5 | 393.8 | 402.1 | 411.4 | ..... | ..... | 381.3 | 387.1 | 393.6 | 400.9 |
| | | 8 | 378.8 | 386.0 | 393.5 | 404.3 | 415.4 | 427.8 | ..... | 381.0 | 387.6 | 395.3 | 404.1 | 413.8 |
| 29 | 26 | 4 | ..... | ..... | ..... | 413.0 | 418.5 | 424.7 | ..... | ..... | ..... | ..... | 412.8 | 417.7 |
| | | 6 | ..... | 409.7 | 416.1 | 423.4 | 431.7 | 441.0 | ..... | ..... | 410.9 | 416.7 | 423.2 | 430.5 |
| | | 8 | ..... | 415.6 | 424.1 | 433.8 | 444.9 | 457.3 | ..... | 410.5 | 417.2 | 424.9 | 433.7 | 443.3 |
| 30 | 27 | 4 | ..... | ..... | ..... | 443.7 | 449.3 | 455.5 | ..... | ..... | ..... | ..... | 443.8 | 448.4 |
| | | 6 | ..... | ..... | 446.8 | 454.1 | 462.5 | 471.8 | ..... | ..... | ..... | 447.4 | 454.0 | 461.3 |
| | | 8 | ..... | 446.3 | 454.8 | 464.6 | 475.7 | 488.1 | ..... | ..... | 447.9 | 455.6 | 464.4 | 474.1 |



## SQUARE CORED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## LOS ANGELES BUILDING CODE REQUIREMENTS

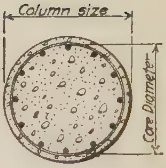
$$P = Af_c[1+(n-1)p]$$

***1:6 mixture***
$n = 15$
$f_c = 550$

| Size of column (inches) | Size of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 9 | 4 | 56.6 | 61.9 | 68.1 | 75.4 | ..... | ..... | 54.0 | 58.2 | 63.1 | 68.7 | 75.2 | |
| 13 | 10 | 4 | 67.0 | 72.3 | 78.6 | 85.8 | ..... | ..... | 64.5 | 68.6 | 73.5 | 79.2 | 85.6 | 92.8 |
| | | 6 | 73.0 | 81.0 | 90.3 | ..... | ..... | ..... | 69.2 | 75.4 | 82.8 | 91.3 | | |
| | | 8 | 79.0 | 89.7 | ..... | ..... | ..... | ..... | 73.9 | 82.2 | 92.0 | | | |
| 14 | 11 | 4 | 78.6 | 83.9 | 90.1 | 97.4 | 105.5 | ..... | 76.0 | 80.2 | 85.1 | 90.7 | 97.2 | 104.4 |
| | | 6 | 84.5 | 92.6 | 101.9 | 112.8 | ..... | ..... | 80.7 | 87.0 | 94.3 | 102.8 | 112.4 | |
| | | 8 | 90.6 | 101.2 | ..... | ..... | ..... | ..... | 85.4 | 93.7 | 103.6 | | | |
| 15 | 12 | 4 | 91.2 | 96.5 | 102.8 | 110.0 | 118.2 | 127.3 | ..... | 92.8 | 97.8 | 103.4 | 109.8 | 117.0 |
| | | 6 | 97.2 | 105.2 | 114.5 | 125.4 | ..... | ..... | 93.4 | 99.6 | 107.0 | 116.5 | 125.1 | |
| | | 8 | 103.2 | 113.9 | 126.3 | ..... | ..... | ..... | 98.1 | 106.4 | 116.2 | 127.6 | | |
| 16 | 13 | 4 | ..... | 110.3 | 116.5 | 123.8 | 131.9 | 141.1 | ..... | 106.6 | 111.5 | 117.1 | 123.6 | 130.8 |
| | | 6 | 111.0 | 119.0 | 128.3 | 139.2 | 151.4 | ..... | 107.1 | 113.4 | 120.7 | 129.2 | 138.8 | 149.6 |
| | | 8 | 117.0 | 127.6 | 140.1 | 154.6 | ..... | ..... | 111.8 | 120.1 | 130.0 | 141.3 | 154.2 | |
| 17 | 14 | 4 | ..... | 125.1 | 131.4 | 138.6 | 146.8 | 155.9 | ..... | ..... | 126.4 | 132.0 | 138.4 | 145.6 |
| | | 6 | 125.8 | 133.8 | 143.1 | 154.0 | 166.2 | 180.0 | ..... | 128.2 | 135.6 | 144.1 | 153.7 | 164.5 |
| | | 8 | 131.8 | 142.5 | 154.9 | 169.4 | ..... | ..... | 126.7 | 135.0 | 144.8 | 156.2 | 169.0 | 183.4 |
| 18 | 15 | 4 | ..... | 141.1 | 147.3 | 154.6 | 162.7 | 171.9 | ..... | ..... | 142.3 | 147.9 | 154.4 | 161.6 |
| | | 6 | 141.8 | 149.8 | 159.1 | 170.0 | 182.2 | 196.0 | ..... | 144.2 | 151.5 | 160.0 | 169.6 | 180.4 |
| | | 8 | 147.8 | 158.4 | 170.9 | 185.4 | 201.7 | ..... | 142.6 | 150.9 | 160.8 | 172.1 | 185.0 | 199.4 |
| 19 | 16 | 4 | ..... | ..... | 164.4 | 171.6 | 179.8 | 188.9 | ..... | ..... | ..... | 165.0 | 171.4 | 178.6 |
| | | 6 | ..... | 166.8 | 176.1 | 187.0 | 199.2 | 213.0 | ..... | 161.2 | 168.6 | 177.1 | 186.7 | 197.5 |
| | | 8 | 164.8 | 175.5 | 187.9 | 202.4 | 218.7 | 237.1 | ..... | 168.0 | 177.8 | 189.2 | 202.0 | 216.4 |
| 20 | 17 | 4 | ..... | ..... | 182.5 | 189.8 | 197.9 | 207.1 | ..... | ..... | ..... | 183.1 | 189.6 | 196.8 |
| | | 6 | ..... | 185.0 | 194.3 | 205.2 | 217.4 | 231.2 | ..... | ..... | 186.7 | 195.2 | 204.8 | 215.6 |
| | | 8 | 183.0 | 193.6 | 206.1 | 220.6 | 236.9 | 255.2 | ..... | 186.1 | 196.0 | 207.3 | 220.2 | 234.6 |
| 21 | 18 | 4 | ..... | ..... | ..... | 209.0 | 217.2 | 226.3 | ..... | ..... | ..... | ..... | 208.8 | 216.0 |
| | | 6 | ..... | 204.2 | 213.5 | 224.4 | 236.6 | 250.4 | ..... | ..... | 206.0 | 214.5 | 224.1 | 234.8 |
| | | 8 | ..... | 212.9 | 225.3 | 239.8 | 256.1 | 274.5 | ..... | 205.4 | 215.2 | 226.6 | 239.4 | 253.8 |
| 22 | 19 | 4 | ..... | ..... | ..... | 229.4 | 237.5 | 246.7 | ..... | ..... | ..... | ..... | 229.2 | 236.4 |
| | | 6 | ..... | ..... | 233.9 | 244.8 | 257.0 | 270.8 | ..... | ..... | 226.3 | 234.8 | 244.4 | 255.2 |
| | | 8 | ..... | 233.2 | 245.7 | 260.2 | 276.5 | 294.8 | ..... | ..... | 235.6 | 246.9 | 259.8 | 274.2 |
| 23 | 20 | 4 | ..... | ..... | ..... | 250.8 | 259.0 | 268.1 | ..... | ..... | ..... | ..... | 250.6 | 257.8 |
| | | 6 | ..... | ..... | 255.3 | 266.2 | 278.5 | 292.2 | ..... | ..... | ..... | 256.3 | 265.9 | 276.7 |
| | | 8 | ..... | 254.7 | 267.1 | 281.6 | 297.9 | 316.3 | ..... | ..... | 257.0 | 268.4 | 281.2 | 295.6 |
| 24 | 21 | 4 | ..... | ..... | ..... | ..... | 281.5 | 290.7 | ..... | ..... | ..... | ..... | ..... | 280.4 |
| | | 6 | ..... | ..... | 277.9 | 288.8 | 301.0 | 314.8 | ..... | ..... | .... | 278.8 | 288.4 | 299.2 |
| | | 8 | ..... | 277.2 | 289.7 | 304.2 | 320.5 | 338.8 | ..... | ..... | 279.6 | 290.9 | 303.8 | 318.2 |
| 25 | 22 | 4 | ..... | ..... | ..... | ..... | 305.2 | 314.3 | ..... | ..... | ..... | ..... | ..... | 304.0 |
| | | 6 | ..... | ..... | ..... | 312.4 | 324.6 | 338.4 | ..... | ..... | ..... | ..... | 312.1 | 322.9 |
| | | 8 | ..... | ..... | 313.3 | 327.8 | 344.1 | 362.5 | ..... | ..... | ..... | 314.6 | 327.4 | 341.8 |
| 26 | 23 | 4 | ..... | ..... | ..... | ..... | ..... | 339.1 | | | | | | |
| | | 6 | ..... | ..... | ..... | 337.2 | 349.4 | 363.2 | ..... | ..... | ..... | ..... | 336.8 | 347.6 |
| | | 8 | ..... | ..... | 338.1 | 352.6 | 368.9 | 387.2 | ..... | ..... | ..... | 339.3 | 352.2 | 366.5 |
| 27 | 24 | 4 | ..... | ..... | ..... | ..... | ..... | 364.9 | | | | | | |
| | | 6 | ..... | ..... | ..... | 363.0 | 375.2 | 389.0 | ..... | ..... | ..... | ..... | 362.7 | 373.4 |
| | | 8 | ..... | ..... | 363.9 | 378.4 | 394.7 | 413.1 | ..... | ..... | ..... | 365.2 | 378.0 | 392.4 |
| 28 | 25 | 4 | ..... | ..... | ..... | ..... | ..... | 391.9 | | | | | | |
| | | 6 | ..... | ..... | ..... | ..... | 402.2 | 416.0 | | | | | | 400.4 |
| | | 8 | ..... | ..... | ..... | 405.4 | 421.7 | 440.0 | ..... | ..... | ..... | 392.1 | 405.0 | 419.4 |
| 29 | 26 | 6 | ..... | ..... | ..... | ..... | 430.2 | 444.0 | ..... | ..... | ..... | ..... | ..... | 428.5 |
| | | 8 | ..... | ..... | ..... | 433.4 | 449.7 | 468.1 | ..... | ..... | ..... | ..... | 433.0 | 447.4 |
| 30 | 27 | 6 | ..... | ..... | ..... | ..... | 459.4 | 473.2 | ..... | ..... | ..... | ..... | ..... | 457.6 |
| | | 8 | ..... | ..... | ..... | 462.6 | 478.9 | 497.2 | ..... | ..... | ..... | ..... | 462.2 | 476.6 |

Below and to right of zig-zag lines, reinforcement is more than 4 per cent.

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# JOINT COMMITTEE RECOMMENDATIONS



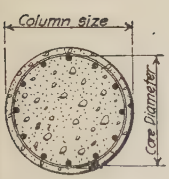
*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 700$

$$P = Af_c[1+(n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 8 | 6 | ..... | ..... | ..... | ..... | ..... | ..... | 53.2 | | | | | |
| 13 | 9 | 6 | 67.5 | ..... | ..... | ..... | ..... | ..... | 62.5 | | | | | |
| | | 8 | ..... | ..... | ..... | ..... | ..... | ..... | 68.6 | | | | | |
| 14 | 10 | 6 | 78.0 | ..... | ..... | ..... | ..... | ..... | 73.0 | 81.0 | | | | |
| | | 8 | 85.6 | ..... | ..... | ..... | ..... | ..... | 79.1 | | | | | |
| 15 | 11 | 6 | 89.5 | 99.6 | ..... | ..... | ..... | ..... | 84.5 | 92.5 | 101.9 | | | |
| | | 8 | 97.1 | ..... | ..... | ..... | ..... | ..... | 90.6 | 101.1 | | | | |
| | | 10 | ..... | ..... | ..... | ..... | ..... | ..... | 96.6 | | | | | |
| 16 | 12 | 6 | 102.2 | 112.3 | ..... | ..... | ..... | ..... | 97.2 | 105.2 | 114.6 | | | |
| | | 8 | 109.8 | 123.3 | ..... | ..... | ..... | ..... | 103.3 | 113.8 | | | | |
| | | 10 | 117.5 | ..... | ..... | ..... | ..... | ..... | 109.3 | 122.5 | | | | |
| 17 | 13 | 6 | 115.9 | 126.0 | 137.9 | ..... | ..... | ..... | 110.9 | 118.9 | 128.3 | 139.1 | | |
| | | 8 | 123.5 | 137.0 | ..... | ..... | ..... | ..... | 116.9 | 127.5 | 140.0 | | | |
| | | 10 | 131.2 | ..... | ..... | ..... | ..... | ..... | 123.0 | 136.2 | | | | |
| 18 | 14 | 6 | 130.7 | 140.8 | 152.7 | 166.5 | ..... | ..... | 125.7 | 133.7 | 143.1 | 153.9 | 166.1 | |
| | | 8 | 138.3 | 151.8 | 167.7 | ..... | ..... | ..... | 131.8 | 142.3 | 154.8 | | | |
| | | 10 | 146.0 | 162.8 | ..... | ..... | ..... | ..... | 137.8 | 151.0 | 166.6 | | | |
| | | 12 | 153.6 | ..... | ..... | ..... | ..... | ..... | 143.8 | 159.7 | | | | |
| 19 | 15 | 6 | 146.7 | 156.8 | 168.7 | 182.5 | ..... | ..... | 141.7 | 149.7 | 159.1 | 169.9 | 182.1 | |
| | | 8 | 154.3 | 167.8 | 183.7 | ..... | ..... | ..... | 147.8 | 158.3 | 170.8 | 185.3 | | |
| | | 10 | 162.0 | 178.8 | ..... | ..... | ..... | ..... | 153.8 | 167.0 | 182.6 | | | |
| | | 12 | 169.6 | 189.9 | ..... | ..... | ..... | ..... | 159.8 | 175.7 | | | | |
| 20 | 16 | 8 | 171.4 | 184.9 | 200.8 | 219.2 | ..... | ..... | 164.9 | 175.4 | 187.9 | 202.4 | 218.7 | |
| | | 10 | 179.1 | 195.9 | 215.8 | ..... | ..... | ..... | 170.9 | 184.1 | 199.7 | 217.8 | | |
| | | 12 | 186.7 | 206.9 | ..... | ..... | ..... | ..... | 176.9 | 192.8 | 211.5 | | | |
| | | 14 | 194.4 | 218.0 | ..... | ..... | ..... | ..... | 182.9 | 201.4 | | | | |
| 21 | 17 | 8 | 189.5 | 203.0 | 218.9 | 237.3 | ..... | ..... | 183.0 | 193.5 | 206.0 | 220.5 | 236.8 | |
| | | 10 | 197.2 | 214.0 | 233.9 | ..... | ..... | ..... | 189.0 | 202.2 | 217.8 | 235.9 | | |
| | | 12 | 204.8 | 225.0 | ..... | ..... | ..... | ..... | 195.0 | 210.9 | 229.6 | | | |
| | | 14 | 212.5 | 236.1 | ..... | ..... | ..... | ..... | 201.0 | 219.5 | 241.4 | | | |
| 22 | 18 | 8 | 208.8 | 222.3 | 238.2 | 256.6 | 277.4 | ..... | ..... | 212.8 | 225.3 | 239.8 | 256.1 | 274.4 |
| | | 10 | 216.5 | 233.3 | 253.2 | 276.2 | ..... | ..... | 208.3 | 221.5 | 237.1 | 255.2 | 275.6 | |
| | | 12 | 224.1 | 244.4 | 268.2 | ..... | ..... | ..... | 214.3 | 230.2 | 248.9 | 270.6 | | |
| | | 14 | 231.8 | 255.4 | ..... | ..... | ..... | ..... | 220.3 | 238.8 | 260.7 | | | |
| 23 | 19 | 8 | 229.1 | 242.6 | 258.5 | 276.9 | 297.7 | ..... | ..... | 233.1 | 245.6 | 260.1 | 276.4 | 294.7 |
| | | 10 | 236.8 | 253.6 | 273.5 | 296.5 | ..... | ..... | 228.6 | 241.8 | 257.4 | 275.5 | 295.9 | |
| | | 12 | 244.4 | 264.7 | 288.5 | ..... | ..... | ..... | 234.6 | 250.5 | 269.2 | 290.9 | | |
| | | 14 | 252.1 | 275.7 | 303.5 | ..... | ..... | ..... | 240.6 | 259.1 | 281.0 | 306.3 | | |
| | | 16 | 259.8 | 286.7 | ..... | ..... | ..... | ..... | 246.6 | 267.8 | 292.8 | | | |
| 24 | 20 | 8 | 250.5 | 264.0 | 279.9 | 298.3 | 319.1 | 342.4 | ..... | 254.5 | 267.0 | 281.5 | 297.8 | 316.1 |
| | | 10 | 258.2 | 275.0 | 294.9 | 317.9 | 343.9 | ..... | ..... | 263.2 | 278.8 | 296.9 | 317.3 | 340.1 |
| | | 12 | 265.8 | 286.1 | 309.9 | 337.5 | ..... | ..... | 256.0 | 271.9 | 290.6 | 312.3 | 336.8 | |
| | | 14 | 273.5 | 297.1 | 324.9 | ..... | ..... | ..... | 262.0 | 280.5 | 302.4 | 327.7 | | |
| | | 16 | 281.2 | 308.1 | 339.9 | ..... | ..... | ..... | 268.0 | 289.2 | 314.2 | 343.1 | | |
| 25 | 21 | 10 | 280.8 | 297.6 | 317.5 | 340.5 | 366.5 | ..... | ..... | 285.8 | 301.4 | 319.5 | 339.9 | 362.7 |
| | | 12 | 288.4 | 308.7 | 332.5 | 360.1 | ..... | ..... | 278.6 | 294.5 | 313.2 | 334.9 | 359.4 | |
| | | 14 | 296.1 | 319.7 | 347.5 | ..... | ..... | ..... | 284.6 | 303.1 | 325.0 | 350.3 | | |
| | | 16 | 303.8 | 330.7 | 362.5 | ..... | ..... | ..... | 290.6 | 311.8 | 336.8 | 365.7 | | |



# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS JOINT COMMITTEE RECOMMENDATIONS

$$P = Af_c[1+(n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

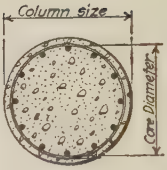
$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 700$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 26 | 22 | 10 | 304.4 | 321.2 | 341.1 | 364.1 | 390.1 | ..... | ..... | 309.4 | 325.0 | 343.1 | 363.5 | 386.3 |
| | | 12 | 312.0 | 332.3 | 356.1 | 383.7 | 414.9 | ..... | ..... | 318.1 | 336.8 | 358.5 | 383.0 | 410.4 |
| | | 14 | 319.7 | 343.3 | 371.1 | 403.3 | ..... | ..... | 308.2 | 326.7 | 348.6 | 373.9 | 402.5 | |
| | | 16 | 327.4 | 354.3 | 386.1 | ..... | ..... | ..... | 314.2 | 335.4 | 360.4 | 389.3 | | |
| | | 18 | 335.0 | 365.3 | 401.1 | ..... | ..... | ..... | 320.2 | 344.0 | 372.2 | 404.6 | | |
| 27 | 23 | 10 | ..... | 346.0 | 365.9 | 388.9 | 414.9 | 444.0 | ..... | 334.2 | 349.8 | 367.9 | 388.3 | 411.1 |
| | | 12 | ..... | 357.1 | 380.9 | 408.5 | 439.7 | ..... | ..... | 342.9 | 361.6 | 383.3 | 407.8 | 435.2 |
| | | 14 | ..... | 368.1 | 395.9 | 428.1 | ..... | ..... | ..... | 351.5 | 373.4 | 398.7 | 427.3 | |
| | | 16 | ..... | 379.1 | 410.9 | 447.7 | ..... | ..... | ..... | 360.2 | 385.2 | 414.1 | 446.8 | |
| | | 18 | ..... | 390.1 | 425.9 | ..... | ..... | ..... | ..... | 368.8 | 397.0 | 429.4 | | |
| 28 | 24 | 10 | ..... | 371.8 | 391.7 | 414.7 | 440.7 | 469.8 | ..... | ..... | 375.6 | 393.7 | 414.1 | 436.9 |
| | | 12 | ..... | 382.9 | 406.7 | 434.3 | 465.5 | ..... | ..... | 368.7 | 387.4 | 409.1 | 433.6 | 461.0 |
| | | 14 | ..... | 393.9 | 421.7 | 453.9 | 490.3 | ..... | ..... | 377.3 | 399.2 | 424.5 | 453.1 | 485.0 |
| | | 16 | ..... | 404.9 | 436.7 | 473.5 | ..... | ..... | ..... | 386.0 | 411.0 | 439.9 | 472.6 | |
| | | 18 | ..... | 315.9 | 451.7 | 493.1 | ..... | ..... | ..... | 394.6 | 422.8 | 455.2 | 492.0 | |
| 29 | 25 | 10 | ..... | 398.7 | 418.6 | 441.6 | 476.6 | 496.7 | ..... | ..... | 402.5 | 420.6 | 441.0 | 463.8 |
| | | 12 | ..... | 409.8 | 433.6 | 461.2 | 492.4 | 527.4 | ..... | 395.6 | 414.3 | 436.0 | 460.5 | 487.9 |
| | | 14 | ..... | 420.8 | 448.6 | 480.8 | 517.2 | ..... | ..... | 404.2 | 426.1 | 451.4 | 480.0 | 511.9 |
| | | 16 | ..... | 431.8 | 463.6 | 500.4 | ..... | ..... | ..... | 412.9 | 437.9 | 466.8 | 499.5 | 536.0 |
| | | 18 | ..... | 442.8 | 478.6 | 520.0 | ..... | ..... | ..... | 421.5 | 449.7 | 482.1 | 518.9 | |
| | | 20 | ..... | 453.9 | 493.7 | ..... | ..... | ..... | ..... | 430.2 | 461.5 | 497.5 | | |
| 30 | 26 | 12 | ..... | 437.8 | 461.6 | 489.2 | 520.4 | 555.4 | ..... | 423.6 | 442.3 | 464.0 | 488.5 | 515.9 |
| | | 14 | ..... | 448.8 | 476.6 | 508.8 | 545.2 | ..... | ..... | 432.2 | 454.1 | 479.4 | 508.0 | 539.9 |
| | | 16 | ..... | 459.8 | 491.6 | 528.4 | 570.0 | ..... | ..... | 440.9 | 465.9 | 494.8 | 527.5 | 564.0 |
| | | 18 | ..... | 470.8 | 506.6 | 548.0 | ..... | ..... | ..... | 449.5 | 477.7 | 510.1 | 546.9 | |
| | | 20 | ..... | 481.9 | 521.7 | 567.6 | ..... | ..... | ..... | 458.2 | 489.5 | 525.5 | 566.4 | |
| 31 | 27 | 12 | ..... | 467.0 | 490.8 | 518.4 | 549.6 | 584.6 | ..... | ..... | 471.5 | 493.2 | 517.7 | 545.1 |
| | | 14 | ..... | 478.0 | 505.8 | 538.0 | 574.4 | 615.2 | ..... | 461.4 | 483.3 | 508.6 | 537.2 | 569.1 |
| | | 16 | ..... | 489.0 | 520.8 | 557.6 | 599.2 | ..... | ..... | 470.1 | 495.1 | 524.0 | 556.7 | 593.2 |
| | | 18 | ..... | 500.0 | 535.8 | 577.2 | 624.1 | ..... | ..... | 478.7 | 506.9 | 539.3 | 576.1 | 617.2 |
| | | 20 | ..... | 511.1 | 550.9 | 596.8 | ..... | ..... | ..... | 487.4 | 518.7 | 554.7 | 595.6 | |
| | | 22 | ..... | 522.1 | 565.9 | 616.4 | ..... | ..... | ..... | 496.1 | 530.4 | 570.1 | 615.1 | |
| 32 | 28 | 12 | ..... | 497.3 | 521.1 | 548.7 | 579.9 | 614.9 | ..... | ..... | 501.8 | 523.5 | 548.0 | 575.4 |
| | | 14 | ..... | 508.3 | 536.1 | 568.3 | 604.7 | 645.5 | ..... | 491.7 | 513.6 | 538.9 | 567.5 | 599.4 |
| | | 16 | ..... | 519.3 | 551.1 | 587.9 | 629.5 | ..... | ..... | 500.4 | 525.4 | 554.3 | 587.0 | 623.5 |
| | | 18 | ..... | 530.3 | 566.1 | 607.5 | 654.4 | ..... | ..... | 509.0 | 537.2 | 569.6 | 606.4 | 647.5 |
| | | 20 | ..... | 541.4 | 581.2 | 627.1 | ..... | ..... | ..... | 517.7 | 549.0 | 585.0 | 625.9 | 671.6 |
| | | 22 | ..... | 552.4 | 596.2 | 646.7 | ..... | ..... | ..... | 526.4 | 560.7 | 600.4 | 645.4 | |
| 33 | 29 | 12 | ..... | 528.6 | 552.4 | 580.0 | 611.2 | 646.2 | ..... | ..... | 533.1 | 554.8 | 579.3 | 606.7 |
| | | 14 | ..... | 539.6 | 567.4 | 599.6 | 636.0 | 676.8 | ..... | ..... | 544.9 | 570.2 | 598.8 | 630.7 |
| | | 16 | ..... | 550.6 | 582.4 | 619.2 | 660.8 | 707.4 | ..... | 531.7 | 556.7 | 585.6 | 618.3 | 654.8 |
| | | 18 | ..... | 561.6 | 597.4 | 638.8 | 685.7 | ..... | ..... | 540.3 | 568.5 | 600.9 | 637.7 | 678.8 |
| | | 20 | ..... | 572.7 | 612.5 | 658.4 | 710.5 | ..... | ..... | 549.0 | 580.3 | 616.3 | 657.2 | 702.9 |
| | | 22 | ..... | 583.7 | 627.5 | 678.0 | ..... | ..... | ..... | 557.7 | 592.0 | 631.7 | 676.7 | |
| 34 | 30 | 12 | ..... | ..... | 584.8 | 612.4 | 643.6 | 678.6 | ..... | ..... | 565.5 | 587.2 | 611.7 | 639.1 |
| | | 14 | ..... | 572.0 | 599.8 | 632.0 | 668.4 | 709.2 | ..... | ..... | 577.3 | 602.6 | 631.2 | 663.1 |
| | | 16 | ..... | 583.0 | 614.8 | 651.6 | 693.2 | 739.8 | ..... | 564.1 | 589.1 | 618.0 | 650.7 | 687.2 |
| | | 18 | ..... | 594.0 | 629.8 | 671.2 | 718.1 | 770.4 | ..... | 572.7 | 600.9 | 633.3 | 670.1 | 711.2 |
| | | 20 | ..... | 605.1 | 644.9 | 690.8 | 742.9 | ..... | ..... | 581.4 | 612.7 | 648.7 | 689.6 | 735.3 |
| | | 22 | ..... | 616.1 | 659.9 | 710.4 | 767.7 | ..... | ..... | 590.1 | 624.4 | 664.1 | 709.1 | 759.3 |
| | | 24 | ..... | 627.1 | 674.9 | 730.0 | ..... | ..... | ..... | 598.7 | 636.2 | 679.5 | 728.6 | |

**COLUMNS**

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# JOINT COMMITTEE RECOMMENDATIONS



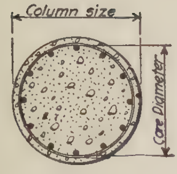
*2000-lb. concrete*
*1:6 mixture*
$n=15$
$f_c=700$

$$P=Af_c[1+(n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right)=10$$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 35 | 31 | 14 | ..... | 605.6 | 633.4 | 665.6 | 702.0 | 742.8 | ..... | ..... | 610.9 | 636.2 | 664.8 | 696.7 |
| | | 16 | ..... | 616.6 | 648.4 | 685.2 | 726.8 | 773.4 | ..... | ..... | 622.7 | 651.6 | 684.3 | 720.8 |
| | | 18 | ..... | 627.6 | 663.4 | 704.8 | 751.7 | 804.0 | ..... | 606.3 | 634.5 | 666.9 | 703.7 | 744.8 |
| | | 20 | ..... | 638.7 | 678.5 | 724.4 | 776.5 | ..... | ..... | 615.0 | 646.3 | 682.3 | 723.2 | 768.9 |
| | | 22 | ..... | 649.7 | 693.5 | 744.0 | 801.3 | ..... | ..... | 623.7 | 658.0 | 697.7 | 742.7 | 792.9 |
| | | 24 | ..... | 660.7 | 708.5 | 763.6 | ..... | ..... | ..... | 632.3 | 669.8 | 713.1 | 762.2 | 817.0 |
| 36 | 32 | 14 | ..... | ..... | 667.9 | 700.1 | 736.5 | 777.3 | ..... | ..... | 645.4 | 670.7 | 699.3 | 731.2 |
| | | 16 | ..... | ..... | 682.9 | 719.7 | 761.3 | 807.9 | ..... | ..... | 657.2 | 686.1 | 718.8 | 755.3 |
| | | 18 | ..... | ..... | 697.9 | 739.3 | 786.2 | 838.5 | ..... | ..... | 669.0 | 701.4 | 738.2 | 779.3 |
| | | 20 | ..... | ..... | 713.0 | 758.9 | 811.0 | 869.2 | ..... | ..... | 680.8 | 716.8 | 757.7 | 803.4 |
| | | 22 | ..... | ..... | 728.0 | 778.5 | 835.8 | ..... | ..... | ..... | 692.5 | 732.2 | 777.2 | 827.4 |
| | | 24 | ..... | ..... | 743.0 | 798.1 | 860.6 | ..... | ..... | ..... | 704.3 | 747.6 | 796.7 | 851.5 |
| 37 | 33 | 14 | ..... | ..... | 703.7 | 735.9 | 772.3 | 813.1 | ..... | ..... | ..... | 706.5 | 735.1 | 767.0 |
| | | 16 | ..... | ..... | 718.7 | 755.5 | 797.1 | 843.7 | ..... | ..... | 693.0 | 721.9 | 754.6 | 791.1 |
| | | 18 | ..... | ..... | 733.7 | 775.1 | 822.0 | 874.3 | ..... | ..... | 704.8 | 737.2 | 774.0 | 815.1 |
| | | 20 | ..... | ..... | 748.8 | 794.7 | 846.8 | 905.0 | ..... | ..... | 716.6 | 752.6 | 793.5 | 839.2 |
| | | 22 | ..... | ..... | 763.8 | 814.3 | 871.6 | ..... | ..... | ..... | 728.3 | 768.0 | 813.0 | 863.2 |
| | | 24 | ..... | ..... | 778.8 | 833.9 | 896.4 | ..... | ..... | ..... | 740.1 | 783.4 | 832.5 | 887.3 |
| | | 26 | ..... | ..... | 793.8 | 853.5 | 921.2 | ..... | ..... | ..... | 751.9 | 798.8 | 852.0 | 911.3 |
| 38 | 34 | 14 | ..... | ..... | 740.5 | 772.7 | 809.1 | 849.9 | ..... | ..... | ..... | 743.3 | 771.9 | 803.8 |
| | | 16 | ..... | ..... | 755.5 | 792.3 | 833.9 | 880.5 | ..... | ..... | 729.8 | 758.7 | 791.4 | 827.9 |
| | | 18 | ..... | ..... | 770.5 | 811.9 | 858.8 | 911.1 | ..... | ..... | 741.6 | 774.0 | 810.8 | 851.9 |
| | | 20 | ..... | ..... | 785.6 | 831.5 | 883.6 | 941.8 | ..... | ..... | 753.4 | 789.4 | 830.3 | 876.0 |
| | | 22 | ..... | ..... | 800.6 | 851.1 | 908.4 | 972.4 | ..... | ..... | 765.1 | 804.8 | 849.8 | 900.0 |
| | | 24 | ..... | ..... | 815.6 | 870.7 | 933.2 | ..... | ..... | ..... | 776.9 | 820.2 | 869.3 | 924.1 |
| | | 26 | ..... | ..... | 830.6 | 890.3 | 958.0 | ..... | ..... | ..... | 788.7 | 835.6 | 888.8 | 948.1 |
| 39 | 35 | 14 | ..... | ..... | 778.5 | 810.7 | 847.1 | 887.9 | ..... | ..... | ..... | 781.3 | 809.9 | 841.8 |
| | | 16 | ..... | ..... | 793.5 | 830.3 | 871.9 | 918.5 | ..... | ..... | 767.8 | 796.7 | 829.4 | 865.9 |
| | | 18 | ..... | ..... | 808.5 | 849.9 | 896.8 | 949.1 | ..... | ..... | 779.6 | 812.0 | 848.8 | 889.9 |
| | | 20 | ..... | ..... | 823.6 | 869.5 | 921.6 | 979.8 | ..... | ..... | 791.4 | 827.4 | 868.3 | 914.0 |
| | | 22 | ..... | ..... | 838.6 | 889.1 | 946.4 | 1010 | ..... | ..... | 803.1 | 842.8 | 887.8 | 938.0 |
| | | 24 | ..... | ..... | 853.6 | 908.7 | 971.2 | 1041 | ..... | ..... | 814.9 | 858.2 | 907.3 | 962.1 |
| | | 26 | ..... | ..... | 868.6 | 928.3 | 996.0 | ..... | ..... | ..... | 826.7 | 873.6 | 926.8 | 986.1 |
| 40 | 36 | 16 | ..... | ..... | 832.5 | 869.3 | 910.9 | 957.5 | ..... | ..... | ..... | 835.7 | 868.4 | 904.9 |
| | | 18 | ..... | ..... | 847.5 | 888.9 | 935.8 | 988.1 | ..... | ..... | 818.6 | 851.0 | 887.8 | 928.9 |
| | | 20 | ..... | ..... | 862.6 | 908.5 | 960.6 | 1019 | ..... | ..... | 830.4 | 866.4 | 907.3 | 953.0 |
| | | 22 | ..... | ..... | 877.6 | 928.1 | 985.4 | 1049 | ..... | ..... | 842.1 | 881.8 | 926.8 | 977.0 |
| | | 24 | ..... | ..... | 892.6 | 947.7 | 1010 | 1080 | ..... | ..... | 853.9 | 897.2 | 946.3 | 1001 |
| | | 26 | ..... | ..... | 907.6 | 967.3 | 1035 | 1111 | ..... | ..... | 865.7 | 912.6 | 965.8 | 1025 |
| | | 28 | ..... | ..... | 922.6 | 986.9 | 1060 | ..... | ..... | ..... | 877.5 | 928.0 | 985.3 | 1049 |
| 41 | 37 | 16 | ..... | ..... | 872.6 | 909.4 | 951.0 | 997.6 | ..... | ..... | ..... | 875.8 | 908.5 | 945.0 |
| | | 18 | ..... | ..... | 887.6 | 929.0 | 975.9 | 1028 | ..... | ..... | 858.7 | 891.1 | 927.9 | 969.0 |
| | | 20 | ..... | ..... | 902.7 | 948.6 | 1001 | 1059 | ..... | ..... | 870.5 | 906.5 | 947.4 | 993.1 |
| | | 22 | ..... | ..... | 917.7 | 968.2 | 1025 | 1089 | ..... | ..... | 882.2 | 921.9 | 966.9 | 1017 |
| | | 24 | ..... | ..... | 932.7 | 987.8 | 1050 | 1120 | ..... | ..... | 894.0 | 937.3 | 986.4 | 1041 |
| | | 26 | ..... | ..... | 947.7 | 1007 | 1075 | 1151 | ..... | ..... | 905.8 | 952.2 | 1006 | 1065 |
| | | 28 | ..... | ..... | 962.7 | 1027 | 1100 | ..... | ..... | ..... | 917.6 | 968.1 | 1025 | 1089 |
| 42 | 38 | 16 | ..... | ..... | 913.9 | 950.7 | 992.3 | 1039 | ..... | ..... | ..... | 917.1 | 949.8 | 986.3 |
| | | 18 | ..... | ..... | 928.9 | 970.3 | 1017 | 1069 | ..... | ..... | ..... | 932.4 | 969.2 | 1010 |
| | | 20 | ..... | ..... | 944.0 | 989.9 | 1042 | 1100 | ..... | ..... | 911.8 | 947.8 | 988.7 | 1034 |
| | | 22 | ..... | ..... | 959.0 | 1009 | 1067 | 1131 | ..... | ..... | 923.5 | 963.2 | 1008 | 1058 |
| | | 24 | ..... | ..... | 974.0 | 1029 | 1092 | 1161 | ..... | ..... | 935.3 | 978.6 | 1028 | 1083 |
| | | 26 | ..... | ..... | 989.0 | 1049 | 1116 | 1192 | ..... | ..... | 947.1 | 994.0 | 1047 | 1107 |
| | | 28 | ..... | ..... | 1004 | 1068 | 1141 | 1223 | ..... | ..... | 958.9 | 1009 | 1067 | 1131 |
| | | 30 | ..... | ..... | 1019 | 1088 | 1166 | ..... | ..... | ..... | 970.7 | 1025 | 1086 | 1155 |



# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# JOINT COMMITTEE RECOMMENDATIONS

$$P = Af_c[1+(n-1)p]$$

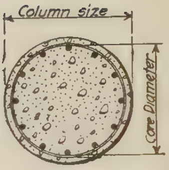
*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 700$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 43 | 39 | 16 | ..... | ..... | 956.2 | 993.0 | 1035 | 1081 | ..... | ..... | ..... | 959.4 | 992.1 | 1029 |
| | | 18 | ..... | ..... | 971.2 | 1012 | 1060 | 1112 | ..... | ..... | ..... | 974.7 | 1012 | 1053 |
| | | 20 | ..... | ..... | 986.3 | 1032 | 1084 | 1143 | ..... | ..... | 954.1 | 990.1 | 1031 | 1077 |
| | | 22 | ..... | ..... | 1001 | 1052 | 1109 | 1173 | ..... | ..... | 965.8 | 1005 | 1051 | 1101 |
| | | 24 | ..... | ..... | 1016 | 1071 | 1134 | 1204 | ..... | ..... | 977.6 | 1021 | 1070 | 1125 |
| | | 26 | ..... | ..... | 1031 | 1091 | 1159 | 1234 | ..... | ..... | 989.4 | 1036 | 1090 | 1149 |
| | | 28 | ..... | ..... | 1046 | 1111 | 1184 | 1265 | ..... | ..... | 1001 | 1052 | 1109 | 1173 |
| | | 30 | ..... | ..... | 1061 | 1130 | 1208 | 1296 | ..... | ..... | 1013 | 1067 | 1128 | 1197 |
| 44 | 40 | 16 | ..... | ..... | ..... | 1036 | 1078 | 1125 | ..... | ..... | ..... | 1003 | 1036 | 1072 |
| | | 18 | ..... | ..... | 1015 | 1056 | 1103 | 1155 | ..... | ..... | ..... | 1018 | 1055 | 1096 |
| | | 20 | ..... | ..... | 1030 | 1076 | 1128 | 1186 | ..... | ..... | ..... | 1034 | 1074 | 1120 |
| | | 22 | ..... | ..... | 1045 | 1095 | 1153 | 1217 | ..... | ..... | 1009 | 1049 | 1094 | 1144 |
| | | 24 | ..... | ..... | 1060 | 1115 | 1178 | 1247 | ..... | ..... | 1021 | 1064 | 1113 | 1168 |
| | | 26 | ..... | ..... | 1075 | 1134 | 1202 | 1278 | ..... | ..... | 1033 | 1080 | 1133 | 1192 |
| | | 28 | ..... | ..... | 1090 | 1154 | 1227 | 1308 | ..... | ..... | 1045 | 1095 | 1152 | 1216 |
| | | 30 | ..... | ..... | 1105 | 1174 | 1252 | 1339 | ..... | ..... | 1056 | 1110 | 1172 | 1240 |
| 45 | 41 | 18 | ..... | ..... | 1059 | 1101 | 1148 | 1200 | ..... | ..... | ..... | 1063 | 1100 | 1141 |
| | | 20 | ..... | ..... | 1074 | 1120 | 1172 | 1231 | ..... | ..... | ..... | 1078 | 1119 | 1165 |
| | | 22 | ..... | ..... | 1089 | 1140 | 1197 | 1261 | ..... | ..... | 1054 | 1094 | 1139 | 1189 |
| | | 24 | ..... | ..... | 1104 | 1159 | 1222 | 1292 | ..... | ..... | 1066 | 1109 | 1158 | 1213 |
| | | 26 | ..... | ..... | 1119 | 1179 | 1247 | 1322 | ..... | ..... | 1077 | 1124 | 1178 | 1237 |
| | | 28 | ..... | ..... | 1134 | 1199 | 1272 | 1353 | ..... | ..... | 1089 | 1140 | 1197 | 1261 |
| | | 30 | ..... | ..... | 1149 | 1218 | 1296 | 1384 | ..... | ..... | 1101 | 1155 | 1216 | 1285 |
| 46 | 42 | 18 | ..... | ..... | ..... | 1146 | 1193 | 1245 | ..... | ..... | ..... | 1108 | 1145 | 1186 |
| | | 20 | ..... | ..... | 1120 | 1166 | 1218 | 1276 | ..... | ..... | ..... | 1124 | 1165 | 1210 |
| | | 22 | ..... | ..... | 1135 | 1186 | 1243 | 1307 | ..... | ..... | ..... | 1139 | 1184 | 1234 |
| | | 24 | ..... | ..... | 1150 | 1205 | 1268 | 1337 | ..... | ..... | 1111 | 1155 | 1204 | 1258 |
| | | 26 | ..... | ..... | 1165 | 1225 | 1292 | 1368 | ..... | ..... | 1123 | 1170 | 1223 | 1282 |
| | | 28 | ..... | ..... | 1180 | 1244 | 1317 | 1399 | ..... | ..... | 1135 | 1185 | 1243 | 1307 |
| | | 30 | ..... | ..... | 1195 | 1264 | 1342 | 1429 | ..... | ..... | 1147 | 1200 | 1262 | 1331 |
| 47 | 43 | 18 | ..... | ..... | ..... | 1193 | 1240 | 1292 | ..... | ..... | ..... | ..... | 1192 | 1233 |
| | | 20 | ..... | ..... | 1166 | 1213 | 1265 | 1323 | ..... | ..... | ..... | 1170 | 1211 | 1257 |
| | | 22 | ..... | ..... | 1181 | 1232 | 1289 | 1353 | ..... | ..... | ..... | 1186 | 1231 | 1281 |
| | | 24 | ..... | ..... | 1196 | 1252 | 1314 | 1384 | ..... | ..... | ..... | 1201 | 1250 | 1305 |
| | | 26 | ..... | ..... | 1211 | 1271 | 1339 | 1415 | ..... | ..... | 1170 | 1217 | 1270 | 1329 |
| | | 28 | ..... | ..... | 1226 | 1291 | 1364 | 1447 | ..... | ..... | 1182 | 1232 | 1289 | 1353 |
| | | 30 | ..... | ..... | 1441 | 1311 | 1389 | 1476 | ..... | ..... | 1193 | 1247 | 1309 | 1377 |
| 48 | 44 | 18 | ..... | ..... | ..... | 1241 | 1288 | 1340 | ..... | ..... | ..... | ..... | 1240 | 1281 |
| | | 20 | ..... | ..... | 1214 | 1260 | 1313 | 1371 | ..... | ..... | ..... | 1218 | 1259 | 1305 |
| | | 22 | ..... | ..... | 1229 | 1280 | 1337 | 1401 | ..... | ..... | ..... | 1234 | 1279 | 1329 |
| | | 24 | ..... | ..... | 1244 | 1300 | 1362 | 1432 | ..... | ..... | ..... | 1249 | 1298 | 1353 |
| | | 26 | ..... | ..... | 1259 | 1319 | 1387 | 1463 | ..... | ..... | 1218 | 1265 | 1318 | 1377 |
| | | 28 | ..... | ..... | 1274 | 1339 | 1412 | 1493 | ..... | ..... | 1229 | 1280 | 1337 | 1401 |
| | | 30 | ..... | ..... | 1289 | 1358 | 1437 | 1524 | ..... | ..... | 1241 | 1295 | 1357 | 1425 |
| 49 | 45 | 18 | ..... | ..... | ..... | 1290 | 1337 | 1389 | ..... | ..... | ..... | ..... | 1289 | 1330 |
| | | 20 | ..... | ..... | ..... | 1309 | 1361 | 1420 | ..... | ..... | ..... | ..... | 1308 | 1354 |
| | | 22 | ..... | ..... | 1278 | 1329 | 1386 | 1450 | ..... | ..... | ..... | 1283 | 1328 | 1378 |
| | | 24 | ..... | ..... | 1293 | 1349 | 1411 | 1481 | ..... | ..... | ..... | 1298 | 1347 | 1402 |
| | | 26 | ..... | ..... | 1308 | 1368 | 1436 | 1511 | ..... | ..... | ..... | 1313 | 1367 | 1426 |
| | | 28 | ..... | ..... | 1323 | 1388 | 1461 | 1542 | ..... | ..... | 1278 | 1329 | 1386 | 1450 |
| | | 30 | ..... | ..... | 1338 | 1407 | 1485 | 1573 | ..... | ..... | 1290 | 1344 | 1406 | 1474 |
| 50 | 46 | 20 | ..... | ..... | ..... | 1359 | 1411 | 1470 | ..... | ..... | ..... | ..... | 1358 | 1404 |
| | | 22 | ..... | ..... | 1328 | 1379 | 1436 | 1500 | ..... | ..... | ..... | 1333 | 1378 | 1428 |
| | | 24 | ..... | ..... | 1343 | 1399 | 1461 | 1531 | ..... | ..... | ..... | 1348 | 1397 | 1452 |
| | | 26 | ..... | ..... | 1358 | 1418 | 1486 | 1561 | ..... | ..... | ..... | 1363 | 1417 | 1476 |
| | | 28 | ..... | ..... | 1373 | 1438 | 1511 | 1592 | ..... | ..... | 1328 | 1379 | 1436 | 1500 |
| | | 30 | ..... | ..... | 1388 | 1457 | 1535 | 1623 | ..... | ..... | 1340 | 1394 | 1456 | 1524 |

## ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## JOINT COMMITTEE RECOMMENDATIONS



*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 870$

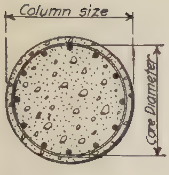
$$P = Af_c[1 + (n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods ⅝ | Square rods ¾ | Square rods ⅞ | Square rods 1 | Square rods 1⅛ | Square rods 1¼ | Round rods ⅝ | Round rods ¾ | Round rods ⅞ | Round rods 1 | Round rods 1⅛ | Round rods 1¼ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 8 | 6 | .... | .... | .... | .... | .... | .... | 61 | | | | | |
| 13 | 9 | 6 | 78 | .... | .... | .... | .... | .... | 73 | | | | | |
| | | 8 | .... | .... | .... | .... | .... | .... | 79 | | | | | |
| 14 | 10 | 6 | 91 | .... | .... | .... | .... | .... | 86 | 94 | | | | |
| | | 8 | 98 | .... | .... | .... | .... | .... | 92 | | | | | |
| 15 | 11 | 6 | 105 | 115 | .... | .... | .... | .... | 100 | 108 | 117 | | | |
| | | 8 | 113 | .... | .... | .... | .... | .... | 106 | 116 | | | | |
| | | 10 | .... | .... | .... | .... | .... | .... | 112 | | | | | |
| 16 | 12 | 6 | 121 | 131 | .... | .... | .... | .... | 116 | 124 | 133 | | | |
| | | 8 | 128 | 141 | .... | .... | .... | .... | 122 | 132 | | | | |
| | | 10 | 136 | .... | .... | .... | .... | .... | 128 | 141 | | | | |
| 17 | 13 | 6 | 138 | 148 | 159 | .... | .... | .... | 133 | 141 | 150 | 161 | | |
| | | 8 | 145 | 158 | .... | .... | .... | .... | 139 | 149 | 161 | | | |
| | | 10 | 153 | .... | .... | .... | .... | .... | 145 | 158 | | | | |
| 18 | 14 | 6 | 156 | 166 | 178 | 191 | .... | .... | 152 | 159 | 168 | 179 | 191 | |
| | | 8 | 164 | 177 | 193 | .... | .... | .... | 157 | 168 | 180 | | | |
| | | 10 | 171 | 189 | .... | .... | .... | .... | 163 | 176 | 191 | | | |
| | | 12 | 179 | .... | .... | .... | .... | .... | 169 | 185 | | | | |
| 19 | 15 | 6 | 176 | 186 | 198 | 211 | .... | .... | 171 | 179 | 188 | 199 | 211 | |
| | | 8 | 184 | 197 | 212 | .... | .... | .... | 177 | 188 | 200 | 214 | | |
| | | 10 | 191 | 208 | .... | .... | .... | .... | 183 | 196 | 211 | | | |
| | | 12 | 199 | 218 | .... | .... | .... | .... | 189 | 204 | | | | |
| 20 | 16 | 8 | 205 | 218 | 234 | 252 | .... | .... | 198 | 209 | 221 | 235 | 251 | |
| | | 10 | 212 | 229 | 248 | .... | .... | .... | 204 | 217 | 233 | 250 | | |
| | | 12 | 220 | 240 | .... | .... | .... | .... | 210 | 226 | 244 | | | |
| | | 14 | 227 | 250 | .... | .... | .... | .... | 216 | 234 | | | | |
| 21 | 17 | 8 | 227 | 241 | 256 | 274 | .... | .... | 221 | 231 | 244 | 258 | 274 | |
| | | 10 | 235 | 251 | 271 | .... | .... | .... | 227 | 240 | 255 | 273 | | |
| | | 12 | 242 | 262 | .... | .... | .... | .... | 233 | 248 | 267 | | | |
| | | 14 | 250 | 273 | .... | .... | .... | .... | 239 | 257 | 278 | | | |
| 22 | 18 | 8 | 251 | 264 | 280 | 298 | 318 | .... | .... | 255 | 267 | 282 | 298 | 315 |
| | | 10 | 259 | 275 | 295 | 317 | .... | .... | 251 | 264 | 279 | 297 | 317 | |
| | | 12 | 266 | 286 | 309 | .... | .... | .... | 257 | 272 | 290 | 312 | | |
| | | 14 | 274 | 297 | .... | .... | .... | .... | 263 | 281 | 302 | | | |
| 23 | 19 | 8 | 277 | 290 | 305 | 323 | 344 | .... | .... | 280 | 293 | 307 | 323 | 341 |
| | | 10 | 284 | 300 | 320 | 342 | .... | .... | 276 | 289 | 304 | 322 | 342 | |
| | | 12 | 292 | 311 | 335 | .... | .... | .... | 282 | 297 | 316 | 337 | | |
| | | 14 | 299 | 322 | 349 | .... | .... | .... | 288 | 306 | 327 | 352 | | |
| | | 16 | 306 | 333 | .... | .... | .... | .... | 294 | 314 | 339 | | | |
| 24 | 20 | 8 | 303 | 316 | 332 | 350 | 370 | .... | .... | 307 | 319 | 333 | 349 | 367 |
| | | 10 | 311 | 327 | 347 | 369 | 394 | .... | .... | 316 | 331 | 349 | 368 | 391 |
| | | 12 | 318 | 238 | 361 | 388 | .... | .... | 309 | 324 | 342 | 364 | 388 | |
| | | 14 | 326 | 349 | 376 | .... | .... | .... | 314 | 333 | 354 | 379 | | |
| | | 16 | 333 | 359 | 391 | .... | .... | .... | 320 | 341 | 365 | 394 | | |
| 25 | 21 | 10 | 339 | 355 | 375 | 397 | 422 | .... | .... | 344 | 359 | 377 | 396 | 419 |
| | | 12 | 346 | 366 | 389 | 416 | .... | .... | 337 | 352 | 370 | 392 | 416 | |
| | | 14 | 354 | 377 | 404 | .... | .... | .... | 342 | 361 | 382 | 407 | | |
| | | 16 | 361 | 388 | 419 | .... | .... | .... | 348 | 369 | 393 | 422 | | |

TABLE 33



# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# JOINT COMMITTEE RECOMMENDATIONS

$$P = Af_c[1+(n-1)p]$$

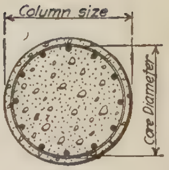
*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 870$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 26 | 22 | 10 | 368 | 385 | 404 | 426 | 452 | .... | ... | 373 | 388 | 406 | 426 | 448 |
| | | 12 | 376 | 395 | 419 | .... | .... | .... | .... | 381 | 400 | 421 | 445 | 472 |
| | | 14 | 383 | 406 | 433 | 446 | 476 | .... | 372 | 390 | 411 | 436 | 464 | |
| | | 16 | 391 | 417 | 448 | .... | .... | .... | 378 | 398 | 423 | 451 | | |
| | | 18 | 398 | 428 | 463 | .... | .... | .... | 384 | 407 | 434 | 466 | | |
| 27 | 23 | 10 | .... | 415 | 435 | 457 | 483 | 511 | .... | 404 | 419 | 437 | 457 | 479 |
| | | 12 | .... | 426 | 449 | 476 | 507 | .... | .... | 412 | 431 | 452 | 476 | 502 |
| | | 14 | .... | 437 | 464 | 495 | .... | .... | .... | 421 | 442 | 467 | 495 | |
| | | 16 | .... | 448 | 479 | 515 | .... | .... | .... | 429 | 454 | 482 | 514 | |
| | | 18 | .... | 458 | 493 | .... | .... | .... | .... | 438 | 465 | 497 | | |
| 28 | 24 | 10 | .... | 447 | 467 | 489 | 515 | 543 | .... | .... | 451 | 469 | 489 | 511 |
| | | 12 | .... | 458 | 482 | 508 | 539 | .... | .... | 444 | 463 | 484 | 508 | 535 |
| | | 14 | .... | 469 | 496 | 528 | 563 | .... | .... | 453 | 474 | 499 | 527 | 558 |
| | | 16 | .... | 480 | 511 | 547 | .... | .... | .... | 461 | 486 | 514 | 546 | |
| | | 18 | | 490 | 525 | 566 | .... | .... | .... | 470 | 497 | 529 | 565 | |
| 29 | 25 | 10 | .... | 481 | 500 | 523 | 548 | 577 | .... | .... | 485 | 502 | 522 | 545 |
| | | 12 | .... | 492 | 515 | 542 | 572 | 607 | .... | 478 | 496 | 517 | 541 | 568 |
| | | 14 | .... | 502 | 530 | 561 | 597 | .... | .... | 486 | 508 | 532 | 560 | 592 |
| | | 16 | .... | 513 | 544 | 580 | .... | .. . | .... | 495 | 519 | 547 | 579 | 615 |
| | | 18 | .... | 524 | 559 | 599 | .... | .... | .... | 503 | 531 | 562 | 598 | |
| | | 20 | .... | 535 | 574 | .... | .... | .... | .... | 512 | 542 | 577 | 517 | |
| 30 | 26 | 12 | .... | 526 | 550 | 577 | 607 | 641 | .... | 513 | 531 | 552 | 576 | 603 |
| | | 14 | .... | 537 | 564 | 596 | 631 | .... | .... | 521 | 542 | 567 | 595 | 626 |
| | | 16 | .... | 548 | 579 | 615 | 656 | .... | .... | 530 | 554 | 582 | 614 | 647 |
| | | 18 | .... | 559 | 594 | 634 | .... | .... | .... | 538 | 565 | 597 | 633 | |
| | | 20 | .... | 570 | 608 | 653 | .... | .... | .... | 546 | 577 | 612 | 650 | |
| 31 | 27 | 12 | .... | 563 | 586 | 613 | 644 | 678 | .... | .... | 567 | 588 | 612 | 639 |
| | | 14 | .... | 574 | 601 | 632 | 668 | 708 | .... | 557 | 579 | 603 | 631 | 663 |
| | | 16 | .... | 584 | 615 | 651 | 692 | .... | . . . | 566 | 590 | 618 | 650 | 686 |
| | | 18 | . . . | 595 | 630 | 670 | 716 | .... | .... | 574 | 602 | 633 | 669 | 710 |
| | | 20 | .... | 606 | 645 | 689 | .... | .... | .... | 583 | 613 | 648 | 688 | |
| | | 22 | .... | 617 | 659 | 709 | .... | .... | .... | 591 | 625 | 664 | 707 | |
| 32 | 28 | 12 | .... | 600 | 624 | 651 | 681 | 715 | .... | .... | 605 | 626 | 650 | 677 |
| | | 14 | .... | 611 | 638 | 670 | 705 | 745 | .... | 595 | 616 | 641 | 669 | 700 |
| | | 16 | .... | 622 | 653 | 689 | 730 | .... | .... | 603 | 628 | 656 | 688 | 724 |
| | | 18 | .... | 633 | 668 | 708 | 754 | .... | .... | 612 | 639 | 671 | 707 | 747 |
| | | 20 | .... | 643 | 682 | 727 | .... | .... | .... | 620 | 651 | 686 | 726 | 771 |
| | | 22 | .... | 654 | 697 | 746 | .... | .... | .... | 629 | 662 | 701 | 745 | |
| 33 | 29 | 12 | .... | 639 | 663 | 689 | 720 | 754 | .... | .... | 644 | 665 | 689 | 716 |
| | | 14 | .... | 650 | 677 | 709 | 744 | 784 | .... | .... | 655 | 680 | 708 | 739 |
| | | 16 | .... | 661 | 692 | 728 | 768 | 814 | .... | 641 | 667 | 695 | 727 | 763 |
| | | 18 | .... | 672 | 707 | 748 | 793 | .... | .... | 651 | 678 | 710 | 746 | 786 |
| | | 20 | .... | 682 | 721 | 766 | 817 | .... | .... | 659 | 690 | 725 | 765 | 810 |
| | | 22 | .... | 693 | 736 | 785 | .... | .... | .... | 668 | 701 | 740 | 784 | |
| 34 | 30 | 12 | .... | .... | 703 | 730 | 760 | 794 | .... | .... | 684 | 705 | 729 | 756 |
| | | 14 | .... | 690 | 718 | 749 | 785 | 824 | .... | .... | 696 | 720 | 748 | 779 |
| | | 16 | .... | 701 | 732 | 768 | 809 | 854 | .... | 683 | 707 | 735 | 767 | 803 |
| | | 18 | .... | 712 | 747 | 787 | 833 | 884 | .... | 691 | 719 | 750 | 786 | 826 |
| | | 20 | .... | 723 | 762 | 806 | 857 | .... | .... | 700 | 730 | 765 | 805 | 850 |
| | | 22 | .... | 733 | 776 | 826 | 881 | .... | .... | 708 | 743 | 780 | 824 | 873 |
| | | 24 | .... | 744 | 791 | 845 | .... | .... | .... | 716 | 753 | 795 | 843 | |

# ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## JOINT COMMITTEE RECOMMENDATIONS



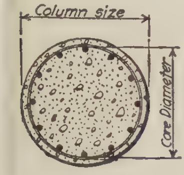
*2500-lb. concrete*
*1:4½ mixture*
*$n = 12$*
*$f_c = 870$*

$$P = Af_c[1+(n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 35 | 31 | 14 | .... | 732 | 760 | 791 | 827 | 866 | .... | .... | 738 | 762 | 790 | 821 |
| | | 16 | .... | 743 | 774 | 810 | 851 | 896 | .... | .... | 749 | 777 | 809 | 845 |
| | | 18 | .... | 754 | 789 | 829 | 875 | 926 | .... | 733 | 761 | 792 | 828 | 868 |
| | | 20 | .... | 765 | 804 | 848 | 899 | .... | .... | 742 | 772 | 807 | 847 | 892 |
| | | 22 | .... | 775 | 819 | 868 | 924 | .... | .... | 750 | 784 | 822 | 866 | 915 |
| | | 24 | .... | 786 | 833 | 887 | .... | .... | .... | 759 | 795 | 837 | 885 | 939 |
| 36 | 32 | 14 | .... | .... | 802 | 834 | 869 | 909 | .... | .... | 780 | 805 | 833 | 864 |
| | | 16 | .... | .... | 817 | 853 | 893 | 939 | .... | .... | 792 | 820 | 852 | 888 |
| | | 18 | .... | .... | 832 | 872 | 918 | 969 | .... | .... | 803 | 835 | 871 | 911 |
| | | 20 | .... | .... | 846 | 891 | 942 | 999 | .... | .... | 815 | 850 | 890 | 935 |
| | | 22 | .... | .... | 861 | 910 | 966 | .... | .... | .... | 826 | 865 | 909 | 958 |
| | | 24 | .... | .... | 876 | 929 | 990 | .... | .... | .... | 838 | 880 | 928 | 982 |
| 37 | 33 | 14 | .... | .... | 847 | 878 | 914 | 953 | .... | .... | .... | 849 | 877 | 909 |
| | | 16 | .... | .... | 861 | 897 | 938 | 983 | .... | .... | 836 | 864 | 896 | 932 |
| | | 18 | .... | .... | 876 | 916 | 962 | 1013 | .... | .... | 848 | 879 | 915 | 956 |
| | | 20 | .... | .... | 891 | 936 | 986 | 1043 | .... | .... | 860 | 894 | 934 | 979 |
| | | 22 | .... | .... | 905 | 955 | 1011 | .... | .... | .... | 871 | 909 | 953 | 1002 |
| | | 24 | .... | .... | 920 | 974 | 1035 | .... | .... | .... | 882 | 925 | 972 | 1026 |
| | | 26 | .... | .... | 935 | 993 | 1060 | .... | .... | .... | 894 | 940 | 991 | 1049 |
| 38 | 34 | 14 | .... | .... | 892 | 924 | 959 | 999 | .... | .... | .... | 895 | 923 | 954 |
| | | 16 | .... | .... | 907 | 943 | 984 | 1029 | .... | .... | 881 | 910 | 942 | 978 |
| | | 18 | .... | .... | 922 | 962 | 1008 | 1059 | .... | .... | 893 | 925 | 961 | 1001 |
| | | 20 | .... | .... | 936 | 981 | 1032 | 1089 | .... | .... | 905 | 940 | 980 | 1025 |
| | | 22 | .... | .... | 951 | 1000 | 1056 | 1119 | .... | .... | 916 | 955 | 999 | 1048 |
| | | 24 | .... | .... | 966 | 1020 | 1081 | .... | .... | .... | 928 | 970 | 1018 | 1072 |
| | | 26 | .... | .... | 980 | 1039 | 1105 | .... | .... | .... | 939 | 985 | 1037 | 1095 |
| 39 | 35 | 14 | .... | .... | 940 | 971 | 1007 | 1046 | .... | .... | .... | 942 | 970 | 1001 |
| | | 16 | .... | .... | 954 | 990 | 1031 | 1076 | .... | .... | 929 | 957 | 989 | 1025 |
| | | 18 | .... | .... | 969 | 1009 | 1055 | 1106 | .... | .... | 941 | 972 | 1008 | 1048 |
| | | 20 | .... | .... | 984 | 1028 | 1079 | 1136 | .... | .... | 952 | 987 | 1027 | 1072 |
| | | 22 | .... | .... | 998 | 1048 | 1103 | 1166 | .... | .... | 964 | 1002 | 1046 | 1095 |
| | | 24 | .... | .... | 1013 | 1067 | 1128 | 1196 | .... | .... | 975 | 1017 | 1065 | 1119 |
| | | 26 | .... | .... | 1028 | 1086 | 1152 | .... | .... | .... | 987 | 1032 | 1084 | 1142 |
| 40 | 36 | 16 | .... | .... | 1003 | 1039 | 1079 | 1125 | .... | .... | .... | 1006 | 1038 | 1073 |
| | | 18 | .... | .... | 1017 | 1058 | 1104 | 1155 | .... | .... | 989 | 1021 | 1057 | 1097 |
| | | 20 | .... | .... | 1032 | 1077 | 1128 | 1185 | .... | .... | 1001 | 1036 | 1076 | 1120 |
| | | 22 | .... | .... | 1047 | 1096 | 1152 | 1215 | .... | .... | 1012 | 1051 | 1095 | 1144 |
| | | 24 | .... | .... | 1061 | 1115 | 1176 | 1244 | .... | .... | 1024 | 1066 | 1114 | 1167 |
| | | 26 | .... | .... | 1076 | 1134 | 1200 | 1274 | .... | .... | 1035 | 1081 | 1133 | 1191 |
| | | 28 | .... | .... | 1091 | 1154 | 1225 | .... | .... | .... | 1047 | 1096 | 1152 | 1214 |
| 41 | 37 | 16 | .... | .... | 1053 | 1089 | 1129 | 1175 | .... | .... | .... | 1056 | 1088 | 1123 |
| | | 18 | .... | .... | 1067 | 1108 | 1154 | 1205 | .... | .... | 1039 | 1071 | 1107 | 1147 |
| | | 20 | .... | .... | 1082 | 1127 | 1178 | 1234 | .... | .... | 1051 | 1086 | 1126 | 1170 |
| | | 22 | .... | .... | 1097 | 1146 | 1202 | 1264 | .... | .... | 1062 | 1101 | 1145 | 1194 |
| | | 24 | .... | .... | 1111 | 1165 | 1226 | 1294 | .... | .... | 1074 | 1116 | 1164 | 1217 |
| | | 26 | .... | .... | 1126 | 1184 | 1250 | 1324 | .... | .... | 1085 | 1131 | 1183 | 1241 |
| | | 28 | .... | .... | 1141 | 1203 | 1275 | .... | .... | .... | 1097 | 1146 | 1202 | 1264 |
| 42 | 38 | 16 | .... | .... | 1104 | 1140 | 1180 | 1226 | .... | .... | .... | 1107 | 1139 | 1175 |
| | | 18 | .... | .... | 1119 | 1159 | 1205 | 1256 | .... | .... | .... | 1122 | 1158 | 1198 |
| | | 20 | .... | .... | 1133 | 1178 | 1229 | 1286 | .... | .... | 1102 | 1137 | 1177 | 1222 |
| | | 22 | .... | .... | 1148 | 1197 | 1253 | 1316 | .... | .... | 1113 | 1152 | 1196 | 1245 |
| | | 24 | .... | .... | 1163 | 1216 | 1277 | 1346 | .... | .... | 1125 | 1167 | 1215 | 1269 |
| | | 26 | .... | .... | 1177 | 1235 | 1302 | 1375 | .... | .... | 1136 | 1182 | 1234 | 1292 |
| | | 28 | .... | .... | 1192 | 1255 | 1326 | 1405 | .... | .... | 1148 | 1197 | 1253 | 1316 |
| | | 30 | .... | .... | 1206 | 1274 | 1350 | .... | .... | .... | 1159 | 1212 | 1272 | 1339 |



## ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS JOINT COMMITTEE RECOMMENDATIONS

$$P = Af_c[1+(n-1)p]$$

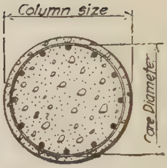
*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 870$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 43 | 39 | 16 | .... | .... | 1157 | 1192 | 1233 | 1279 | .... | .... | .... | 1160 | 1192 | 1227 |
| | | 18 | .... | .... | 1171 | 1212 | 1257 | 1308 | .... | .... | .... | 1175 | 1211 | 1251 |
| | | 20 | .... | .... | 1186 | 1231 | 1282 | 1338 | .... | .... | 1154 | 1190 | 1230 | 1274 |
| | | 22 | .... | .... | 1200 | 1250 | 1306 | 1368 | .... | .... | 1166 | 1205 | 1249 | 1298 |
| | | 24 | .... | .... | 1215 | 1269 | 1330 | 1398 | .... | .... | 1177 | 1220 | 1268 | 1321 |
| | | 26 | .... | .... | 1230 | 1288 | 1354 | 1428 | .... | .... | 1189 | 1235 | 1287 | 1345 |
| | | 28 | .... | .... | 1244 | 1307 | 1378 | 1458 | .... | .... | 1200 | 1250 | 1306 | 1368 |
| | | 30 | .... | .... | 1259 | 1326 | 1403 | 1488 | .... | .... | 1212 | 1265 | 1325 | 1392 |
| 44 | 40 | 16 | .... | .... | .... | 1246 | 1287 | 1332 | .... | .... | .... | 1214 | 1245 | 1281 |
| | | 18 | .... | .... | 1225 | 1266 | 1311 | 1362 | .... | .... | .... | 1229 | 1264 | 1305 |
| | | 20 | .... | .... | 1240 | 1285 | 1335 | 1392 | .... | .... | .... | 1244 | 1283 | 1328 |
| | | 22 | .... | .... | 1254 | 1304 | 1360 | 1422 | .... | .... | 1220 | 1259 | 1303 | 1352 |
| | | 24 | .... | .... | 1269 | 1323 | 1384 | 1452 | .... | .... | 1231 | 1274 | 1322 | 1375 |
| | | 26 | .... | .... | 1284 | 1342 | 1408 | 1482 | .... | .... | 1243 | 1289 | 1341 | 1399 |
| | | 28 | .... | .... | 1298 | 1361 | 1432 | 1512 | .... | .... | 1254 | 1304 | 1360 | 1422 |
| | | 30 | .... | .... | 1313 | 1380 | 1457 | 1542 | .... | .... | 1266 | 1319 | 1379 | 1446 |
| 45 | 41 | 18 | .... | .... | 1281 | 1321 | 1367 | 1418 | .... | .... | .... | 1284 | 1320 | 1360 |
| | | 20 | .... | .... | 1295 | 1340 | 1391 | 1448 | .... | .... | .... | 1299 | 1339 | 1384 |
| | | 22 | .... | .... | 1310 | 1359 | 1415 | 1478 | .... | .... | 1275 | 1314 | 1358 | 1407 |
| | | 24 | .... | .... | 1325 | 1378 | 1439 | 1508 | .... | .... | 1287 | 1329 | 1377 | 1431 |
| | | 26 | .... | .... | 1339 | 1397 | 1464 | 1537 | .... | .... | 1298 | 1344 | 1396 | 1454 |
| | | 28 | .... | .... | 1354 | 1417 | 1488 | 1567 | .... | .... | 1310 | 1359 | 1415 | 1478 |
| | | 30 | .... | .... | 1368 | 1436 | 1512 | 1597 | .... | .... | 1321 | 1374 | 1434 | 1501 |
| 46 | 42 | 18 | .... | .... | .... | 1378 | 1423 | 1474 | .... | .... | .... | 1341 | 1377 | 1417 |
| | | 20 | .... | .... | 1352 | 1397 | 1448 | 1504 | .... | .... | .... | 1356 | 1396 | 1440 |
| | | 22 | .... | .... | 1366 | 1416 | 1472 | 1534 | .... | .... | .... | 1371 | 1415 | 1464 |
| | | 24 | .... | .... | 1381 | 1435 | 1496 | 1564 | .... | .... | 1343 | 1386 | 1434 | 1487 |
| | | 26 | .... | .... | 1396 | 1454 | 1520 | 1594 | .... | .... | 1355 | 1401 | 1453 | 1511 |
| | | 28 | .... | .... | 1410 | 1473 | 1544 | 1624 | .... | .... | 1366 | 1416 | 1472 | 1534 |
| | | 30 | .... | .... | 1425 | 1492 | 1569 | 1654 | .... | .... | 1378 | 1431 | 1491 | 1558 |
| 47 | 43 | 18 | .... | .... | .... | 1436 | 1481 | 1533 | .... | .... | .... | .... | 1435 | 1475 |
| | | 20 | .... | .... | 1410 | 1455 | 1506 | 1562 | .... | .... | .... | 1414 | 1454 | 1498 |
| | | 22 | .... | .... | 1425 | 1474 | 1530 | 1592 | .... | .... | .... | 1429 | 1473 | 1522 |
| | | 24 | .... | .... | 1438 | 1493 | 1554 | 1622 | .... | .... | .... | 1444 | 1492 | 1545 |
| | | 26 | .... | .... | 1454 | 1512 | 1578 | 1652 | .... | .... | 1413 | 1459 | 1511 | 1569 |
| | | 28 | .... | .... | 1469 | 1531 | 1603 | 1682 | .... | .... | 1425 | 1474 | 1530 | 1592 |
| | | 30 | .... | .... | 1483 | 1551 | 1627 | 1712 | .... | .... | 1436 | 1489 | 1549 | 1616 |
| 48 | 44 | 18 | .... | .... | .... | 1495 | 1541 | 1592 | | | .... | .... | 1494 | 1534 |
| | | 20 | .... | .... | 1469 | 1514 | 1565 | 1622 | .... | .... | .... | 1473 | 1513 | 1558 |
| | | 22 | .... | .... | 1484 | 1533 | 1589 | 1652 | .... | .... | .... | 1488 | 1532 | 1581 |
| | | 24 | .... | .... | 1499 | 1553 | 1614 | 1682 | .... | .... | .... | 1503 | 1551 | 1605 |
| | | 26 | .... | .... | 1513 | 1572 | 1638 | 1712 | .... | .... | 1472 | 1518 | 1570 | 1628 |
| | | 28 | .... | .... | 1528 | 1591 | 1662 | 1742 | .... | .... | 1484 | 1533 | 1589 | 1652 |
| | | 30 | .... | .... | 1543 | 1610 | 1686 | 1771 | .... | .... | 1495 | 1548 | 1608 | 1675 |
| 49 | 45 | 18 | .... | .... | .... | 1556 | 1602 | 1653 | .... | .... | .... | .... | 1555 | 1595 |
| | | 20 | .... | .... | .... | 1575 | 1626 | 1683 | .... | .... | .... | .... | 1574 | 1619 |
| | | 22 | .... | .... | 1545 | 1594 | 1650 | 1713 | .... | .... | .... | 1549 | 1593 | 1642 |
| | | 24 | .... | .... | 1560 | 1613 | 1674 | 1743 | .... | .... | .... | 1564 | 1612 | 1666 |
| | | 26 | .... | .... | 1574 | 1632 | 1699 | 1772 | .... | .... | .... | 1579 | 1631 | 1689 |
| | | 28 | .... | .... | 1589 | 1652 | 1723 | 1802 | .... | .... | 1545 | 1594 | 1650 | 1712 |
| | | 30 | .... | .... | 1603 | 1671 | 1747 | 1832 | .... | .... | 1556 | 1609 | 1669 | 1736 |
| 50 | 46 | 20 | .... | .... | .... | 1637 | 1688 | 1745 | .... | .... | .... | .... | 1636 | 1681 |
| | | 22 | .... | .... | 1607 | 1656 | 1712 | 1775 | .... | .... | .... | 1611 | 1655 | 1704 |
| | | 24 | .... | .... | 1622 | 1676 | 1736 | 1805 | .... | .... | .... | 1626 | 1674 | 1728 |
| | | 26 | .... | .... | 1636 | 1695 | 1761 | 1835 | .... | .... | .... | 1641 | 1693 | 1751 |
| | | 28 | .... | .... | 1651 | 1714 | 1785 | 1865 | .... | | 1607 | 1656 | 1712 | 1775 |
| | | 30 | .... | | 1666 | 1733 | 1809 | 1894 | | | 1618 | 1671 | 1731 | 1798 |

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# JOINT COMMITTEE RECOMMENDATIONS



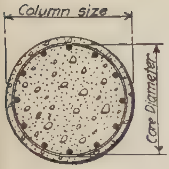
*3000-lb. concrete*
*1:3 mixture*
$n = 10$
$f_c = 1050$

$$P = Af_c[1+(n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 12 | 8 | 6 | .... | .... | .... | .... | .... | .... | 70 | | | | | |
| 13 | 9 | 6 | 89 | .... | .... | .... | .... | .... | 84 | | | | | |
| | | 8 | .... | .... | .... | .... | .... | .... | 90 | | | | | |
| 14 | 10 | 6 | 105 | .... | .... | .... | .... | .... | 100 | 107 | | | | |
| | | 8 | 112 | .... | .... | .... | .... | .... | 105 | | | | | |
| 15 | 11 | 6 | 122 | 132 | .... | .... | .... | .... | 117 | 125 | 134 | | | |
| | | 8 | 129 | .... | .... | .... | .... | .... | 123 | 133 | | | | |
| | | 10 | .... | .... | .... | .... | .... | .... | 129 | | | | | |
| 16 | 12 | 6 | 141 | 151 | .... | .... | .... | .... | 136 | 144 | 153 | | | |
| | | 8 | 148 | 161 | .... | .... | .... | .... | 142 | 152 | | | | |
| | | 10 | 156 | .... | .... | .... | .... | .... | 148 | 161 | | | | |
| 17 | 13 | 6 | 161 | 171 | 183 | .... | .... | .... | 157 | 164 | 173 | 184 | | |
| | | 8 | 169 | 182 | .... | .... | .... | .... | 163 | 173 | 185 | | | |
| | | 10 | 176 | .... | .... | .... | .... | .... | 168 | 181 | | | | |
| 18 | 14 | 6 | 184 | 193 | 205 | 218 | .... | .... | 179 | 187 | 196 | 206 | 218 | |
| | | 8 | 191 | 204 | 219 | .... | .... | .... | 185 | 195 | 207 | | | |
| | | 10 | 199 | 215 | .... | .... | .... | .... | 191 | 203 | 218 | | | |
| | | 12 | 206 | .... | .... | .... | .... | .... | 196 | 212 | | | | |
| 19 | 15 | 6 | 208 | 217 | 229 | 242 | .... | .... | 203 | 211 | 219 | 230 | 242 | |
| | | 8 | 215 | 228 | 243 | .... | .... | .... | 209 | 219 | 231 | 245 | | |
| | | 10 | 222 | 239 | .... | .... | .... | .... | 215 | 227 | 242 | | | |
| | | 12 | 230 | 249 | .... | .... | .... | .... | 220 | 236 | | | | |
| 20 | 16 | 8 | 241 | 243 | 269 | 287 | .... | .... | 234 | 245 | 257 | 271 | 286 | |
| | | 10 | 248 | 254 | 284 | .... | .... | .... | 240 | 253 | 268 | 285 | | |
| | | 12 | 255 | 264 | .... | .... | .... | .... | 246 | 261 | 279 | | | |
| | | 14 | 263 | 275 | .... | .... | .... | .... | 252 | 271 | | | | |
| 21 | 17 | 8 | 268 | 281 | 296 | 314 | .... | .... | 262 | 272 | 284 | 298 | 314 | |
| | | 10 | 275 | 292 | 311 | .... | .... | .... | 267 | 280 | 295 | 313 | | |
| | | 12 | 283 | 302 | .... | .... | .... | .... | 273 | 289 | 307 | | | |
| | | 14 | 290 | 313 | .... | .... | .... | .... | 279 | 298 | 318 | | | |
| 22 | 18 | 8 | 297 | 310 | 325 | 343 | 363 | .... | .... | 301 | 313 | 327 | 342 | 360 |
| | | 10 | 304 | 320 | 340 | 362 | .... | .... | 296 | 309 | 324 | 341 | 361 | |
| | | 12 | 312 | 331 | 354 | .... | .... | .... | 302 | 317 | 335 | 356 | | |
| | | 14 | 319 | 342 | .... | .... | .... | .... | 308 | 327 | 347 | | | |
| 23 | 19 | 8 | 327 | 340 | 356 | 373 | 393 | .... | .... | 331 | 343 | 357 | 373 | 390 |
| | | 10 | 335 | 351 | 370 | 392 | .... | .... | 327 | 339 | 355 | 372 | 392 | |
| | | 12 | 342 | 361 | 384 | .... | .... | .... | 332 | 348 | 366 | 387 | | |
| | | 14 | 349 | 372 | 399 | .... | .... | .... | 338 | 357 | 377 | 402 | | |
| | | 16 | 357 | 383 | .... | .... | .... | .... | 344 | 364 | 389 | | | |
| 24 | 20 | 8 | 359 | 372 | 388 | 406 | 426 | 448 | .... | 363 | 375 | 389 | 405 | 423 |
| | | 10 | 367 | 383 | 402 | 424 | 450 | .... | .... | 372 | 387 | 404 | 424 | 446 |
| | | 12 | 374 | 394 | 417 | 443 | .... | .... | 365 | 380 | 398 | 419 | 443 | |
| | | 14 | 382 | 404 | 431 | .... | .... | .... | 371 | 389 | 409 | 434 | | |
| | | 16 | 389 | 415 | 446 | .... | .... | .... | 376 | 397 | 421 | 449 | | |
| 25 | 21 | 10 | 401 | 417 | 436 | 458 | 483 | .... | .... | 405 | 421 | 438 | 458 | 480 |
| | | 12 | 408 | 428 | 451 | 477 | .... | .... | 399 | 414 | 432 | 453 | 476 | |
| | | 14 | 415 | 438 | 465 | .... | .... | .... | 404 | 423 | 443 | 468 | | |
| | | 16 | 423 | 449 | 479 | .... | .... | .... | 410 | 431 | 455 | 482 | | |



# ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## JOINT COMMITTEE RECOMMENDATIONS

$$P = Af_c[1+(n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

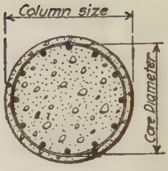
$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

*3000-lb. concrete*
*1:3 mixture*
$n = 10$
$f_c = 1050$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods |  |  |  |  |  | Round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 26 | 22 | 10 | 436 | 452 | 471 | 494 | 519 | .... | .... | 441 | 456 | 473 | 493 | 515 |
|  |  | 12 | 443 | 463 | 486 | 513 | 543 | .... | .... | 449 | 467 | 488 | 512 | 538 |
|  |  | 14 | 451 | 471 | 500 | 531 | .... | .... | 440 | 458 | 479 | 503 | 531 |  |
|  |  | 16 | 458 | 484 | 515 | .... | .... | .... | 445 | 466 | 490 | 518 |  |  |
|  |  | 18 | 466 | 495 | 529 | .... | .... | .... | 451 | 474 | 501 | 533 |  |  |
| 27 | 23 | 10 | .... | 489 | 509 | 531 | 556 | 584 | .... | 478 | 493 | 511 | 530 | 552 |
|  |  | 12 | .... | 500 | 523 | 550 | 580 | .... | .... | 487 | 504 | 525 | 549 | 575 |
|  |  | 14 | .... | 511 | 538 | 569 | .... | .... | .... | 496 | 516 | 540 | 568 |  |
|  |  | 16 | .... | 521 | 552 | 587 | .... | .... | .... | 503 | 527 | 555 | 587 |  |
|  |  | 18 | .... | 532 | 567 | .... | .... | .... | .... | 511 | 539 | 570 |  |  |
| 28 | 24 | 10 | .... | 528 | 547 | 570 | 595 | 623 | .... | .... | 532 | 549 | 569 | 591 |
|  |  | 12 | .... | 539 | 562 | 588 | 619 | .... | .... | 525 | 543 | 564 | 588 | 614 |
|  |  | 14 | .... | 549 | 576 | 607 | 642 | .... | .... | 534 | 555 | 579 | 607 | 637 |
|  |  | 16 | .... | 560 | 591 | 626 | .... | .... | .... | 542 | 566 | 594 | 625 |  |
|  |  | 18 | .... | 571 | 605 | 645 | .... | .... | .... | 550 | 577 | 609 | 644 |  |
| 29 | 25 | 10 | .... | 569 | 588 | 610 | 635 | 663 | .... | .... | 572 | 590 | 609 | 631 |
|  |  | 12 | .... | 579 | 602 | 629 | 659 | 693 | .... | 566 | 584 | 605 | 628 | 655 |
|  |  | 14 | .... | 590 | 617 | 648 | 683 | .... | .... | 575 | 595 | 619 | 647 | 678 |
|  |  | 16 | .... | 601 | 631 | 667 | .... | .... | .... | 582 | 606 | 634 | 666 | 701 |
|  |  | 18 | .... | 611 | 646 | 686 | .... | .... | .... | 591 | 618 | 649 | 685 |  |
|  |  | 20 | .... | 622 | 660 | .... | .... | .... | .... | 599 | 629 | 664 |  |  |
| 30 | 26 | 12 | .... | 621 | 644 | 671 | 701 | 735 | .... | 608 | 626 | 647 | 670 | 697 |
|  |  | 14 | .... | 632 | 659 | 690 | 725 | .... | .... | 617 | 637 | 661 | 689 | 720 |
|  |  | 16 | .... | 643 | 673 | 709 | 749 | .... | .... | 624 | 648 | 676 | 708 | 743 |
|  |  | 18 | .... | 653 | 688 | 728 | .... | .... | .... | 633 | 660 | 691 | 727 |  |
|  |  | 20 | .... | 664 | 702 | 746 | .... | .... | .... | 641 | 671 | 706 | 745 |  |
| 31 | 27 | 12 | .... | 665 | 688 | 715 | 745 | 778 | .... | .... | 669 | 690 | 714 | 740 |
|  |  | 14 | .... | 676 | 703 | 734 | 769 | 808 | .... | 661 | 681 | 705 | 733 | 764 |
|  |  | 16 | .... | 686 | 717 | 752 | 793 | .... | .... | 668 | 692 | 720 | 752 | 787 |
|  |  | 18 | .... | 697 | 731 | 771 | 817 | .... | .... | 676 | 704 | 735 | 770 | 810 |
|  |  | 20 | .... | 708 | 746 | 790 | .... | .... | .... | 685 | 715 | 750 | 789 |  |
|  |  | 22 | .... | 718 | 760 | 809 | .... | .... | .... | 693 | 726 | 765 | 808 |  |
| 32 | 28 | 12 | .... | 710 | 733 | 760 | 790 | 824 | .... | .... | 715 | 736 | 759 | 786 |
|  |  | 14 | .... | 721 | 748 | 779 | 814 | 853 | .... | 706 | 726 | 751 | 778 | 809 |
|  |  | 16 | .... | 732 | 762 | 798 | 838 | .... | .... | 713 | 738 | 765 | 797 | 832 |
|  |  | 18 | .... | 742 | 777 | 817 | 862 | .... | .... | 722 | 749 | 780 | 816 | 855 |
|  |  | 20 | .... | 753 | 791 | 836 | .... | .... | .... | 730 | 760 | 795 | 834 | 879 |
|  |  | 22 | .... | 764 | 806 | 854 | .... | .... | .... | 738 | 772 | 810 | 853 |  |
| 33 | 29 | 12 | .... | 757 | 780 | 807 | 837 | 871 | .... | .... | 762 | 783 | 806 | 833 |
|  |  | 14 | .... | 768 | 795 | 826 | 861 | 900 | .... | .... | 773 | 797 | 825 | 856 |
|  |  | 16 | .... | 779 | 809 | 845 | 885 | 930 | .... | 760 | 784 | 812 | 844 | 879 |
|  |  | 18 | .... | 789 | 824 | 864 | 909 | .... | .... | 769 | 796 | 827 | 863 | 902 |
|  |  | 20 | .... | 800 | 838 | 883 | 933 | .... | .... | 777 | 807 | 842 | 881 | 925 |
|  |  | 22 | .... | 810 | 853 | 901 | .... | .... | .... | 785 | 819 | 857 | 900 |  |
| 34 | 30 | 12 | .... | .... | 829 | 856 | 886 | 919 | .... | .... | 810 | 831 | 855 | 881 |
|  |  | 14 | .... | 817 | 844 | 875 | 910 | 949 | .... | .... | 822 | 846 | 874 | 905 |
|  |  | 16 | .... | 827 | 858 | 893 | 934 | 979 | .... | 809 | 833 | 861 | 893 | 928 |
|  |  | 18 | .... | 838 | 872 | 912 | 958 | 1008 | .... | 817 | 845 | 876 | 911 | 951 |
|  |  | 20 | .... | 849 | 887 | 931 | 981 | .... | .... | 826 | 856 | 891 | 930 | 974 |
|  |  | 22 | .... | 859 | 901 | 950 | 1005 | .... | .... | 834 | 867 | 906 | 949 | 997 |
|  |  | 24 | .... | 870 | 916 | 969 |  | .... | .... | 842 | 879 | 920 | 968 |  |

TABLE 34

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# JOINT COMMITTEE RECOMMENDATIONS



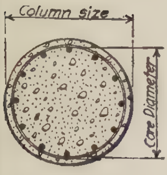
***3000-lb. concrete***
***1:3 mixture***
***$n = 10$***
***$f_c = 1050$***

$$P = Af_c[1+(n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods ⅝ | Square rods ¾ | Square rods ⅞ | Square rods 1 | Square rods 1⅛ | Square rods 1¼ | Round rods ⅝ | Round rods ¾ | Round rods ⅞ | Round rods 1 | Round rods 1⅛ | Round rods 1¼ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **35** | **31** | 14 | .... | 867 | 894 | 925 | 960 | 999 | .... | .... | 872 | 896 | 924 | 955 |
| | | 16 | .... | 878 | 908 | 944 | 984 | 1029 | .... | .... | 883 | 911 | 943 | 978 |
| | | 18 | .... | 888 | 923 | 963 | 1008 | 1058 | .... | 868 | 895 | 926 | 962 | 1001 |
| | | 20 | .... | 899 | 937 | 982 | 1032 | .... | .... | 877 | 906 | 941 | 980 | 1024 |
| | | 22 | .... | 909 | 952 | 1000 | 1056 | .... | .... | 884 | 918 | 956 | 999 | 1048 |
| | | 24 | .... | 920 | 966 | 1019 | .... | .... | .... | 893 | 929 | 971 | 1018 | 1071 |
| **36** | **32** | 14 | .... | .... | 946 | 977 | 1012 | 1051 | .... | .... | 924 | 948 | 976 | 1007 |
| | | 16 | .... | .... | 960 | 996 | 1036 | 1081 | .... | .... | 935 | 963 | 995 | 1030 |
| | | 18 | .... | .... | 975 | 1015 | 1060 | 1110 | .... | .... | 947 | 978 | 1014 | 1053 |
| | | 20 | .... | .... | 989 | 1033 | 1084 | 1140 | .... | .... | 958 | 993 | 1032 | 1076 |
| | | 22 | .... | .... | 1004 | 1052 | 1108 | .... | .... | .... | 969 | 1008 | 1051 | 1100 |
| | | 24 | .... | .... | 1018 | 1071 | 1131 | .... | .... | .... | 981 | 1023 | 1070 | 1123 |
| **37** | 33 | 14 | .... | .... | 999 | 1030 | 1066 | 1105 | .... | .... | ... | 1002 | 1030 | 1060 |
| | | 16 | .... | .... | 1014 | 1049 | 1089 | 1135 | .... | .... | 989 | 1017 | 1048 | 1084 |
| | | 18 | .... | .... | 1028 | 1068 | 1113 | 1164 | .... | .... | 1000 | 1032 | 1067 | 1107 |
| | | 20 | .... | .... | 1043 | 1087 | 1137 | 1193 | .... | .... | 1012 | 1047 | 1086 | 1130 |
| | | 22 | .... | .... | 1057 | 1106 | 1161 | .... | .... | .... | 1023 | 1061 | 1105 | 1153 |
| | | 24 | .... | .... | 1072 | 1125 | 1185 | .... | .... | .... | 1034 | 1076 | 1124 | 1176 |
| | | 26 | .... | .... | 1086 | 1144 | 1209 | .... | .... | .... | 1046 | 1091 | 1142 | 1200 |
| **38** | 34 | 14 | .... | .... | 1055 | 1086 | 1121 | 1160 | .... | .... | ... | 1057 | 1085 | 1116 |
| | | 16 | .... | .... | 1069 | 1105 | 1145 | 1190 | .... | .... | 1044 | 1072 | 1104 | 1139 |
| | | 18 | .... | .... | 1084 | 1123 | 1169 | 1219 | .... | .... | 1056 | 1087 | 1122 | 1162 |
| | | 20 | .... | .... | 1098 | 1142 | 1192 | 1249 | .... | .... | 1067 | 1102 | 1141 | 1185 |
| | | 22 | .... | .... | 1112 | 1161 | 1216 | 1278 | .... | .... | 1078 | 1117 | 1160 | 1208 |
| | | 24 | .... | .... | 1127 | 1180 | 1240 | .... | .... | .... | 1090 | 1131 | 1179 | 1232 |
| | | 26 | .... | .... | 1141 | 1199 | 1264 | .... | .... | .... | 1101 | 1146 | 1198 | 1255 |
| **39** | 35 | 14 | .... | .... | 1111 | 1143 | 1178 | 1217 | .... | .... | .... | 1114 | 1142 | 1173 |
| | | 16 | .... | .... | 1126 | 1161 | 1202 | 1246 | .... | .... | 1101 | 1129 | 1161 | 1196 |
| | | 18 | .... | .... | 1140 | 1180 | 1225 | 1276 | .... | .... | 1112 | 1144 | 1179 | 1219 |
| | | 20 | .... | .... | 1155 | 1199 | 1249 | 1306 | .... | .... | 1124 | 1159 | 1198 | 1242 |
| | | 22 | .... | .... | 1169 | 1218 | 1273 | 1335 | .... | .... | 1135 | 1173 | 1217 | 1265 |
| | | 24 | .... | .... | 1184 | 1237 | 1297 | 1365 | .... | .... | 1147 | 1188 | 1236 | 1289 |
| | | 26 | .... | .... | 1198 | 1256 | 1321 | .... | .... | .... | 1158 | 1203 | 1254 | 1312 |
| 40 | 36 | 16 | .... | .... | 1185 | 1220 | 1260 | 1305 | .... | .... | .... | 1188 | 1219 | 1254 |
| | | 18 | .... | .... | 1199 | 1239 | 1284 | 1335 | .... | .... | 1171 | 1202 | 1238 | 1278 |
| | | 20 | .... | .... | 1213 | 1258 | 1308 | 1364 | .... | .... | 1182 | 1217 | 1257 | 1301 |
| | | 22 | .... | .... | 1228 | 1277 | 1332 | 1394 | .... | .... | 1194 | 1232 | 1275 | 1324 |
| | | 24 | .... | .... | 1242 | 1296 | 1356 | 1423 | .... | .... | 1205 | 1247 | 1294 | 1347 |
| | | 26 | .... | .... | 1257 | 1315 | 1380 | 1453 | .... | .... | 1217 | 1262 | 1313 | 1370 |
| | | 28 | .... | .... | 1271 | 1333 | 1404 | .... | .... | .... | 1228 | 1277 | 1332 | 1394 |
| 41 | 37 | 16 | .... | .... | 1245 | 1280 | 1320 | 1365 | .... | .... | .... | 1248 | 1279 | 1315 |
| | | 18 | .... | .... | 1259 | 1299 | 1344 | 1395 | .... | .... | 1231 | 1263 | 1298 | 1338 |
| | | 20 | .... | .... | 1274 | 1318 | 1368 | 1424 | .... | .... | 1243 | 1277 | 1317 | 1361 |
| | | 22 | .... | .... | 1288 | 1337 | 1392 | 1454 | .... | .... | 1254 | 1292 | 1336 | 1384 |
| | | 24 | .... | .... | 1303 | 1356 | 1416 | 1483 | .... | .... | 1265 | 1307 | 1354 | 1407 |
| | | 26 | .... | .... | 1317 | 1375 | 1464 | 1513 | .... | .... | 1277 | 1322 | 1373 | 1430 |
| | | 28 | .... | .... | 1332 | 1394 | 1488 | .... | .... | .... | 1288 | 1337 | 1392 | 1454 |
| 42 | 38 | 16 | .... | .... | 1307 | 1342 | 1382 | 1427 | .... | .... | .... | 1310 | 1341 | 1376 |
| | | 18 | .... | .... | 1321 | 1361 | 1406 | 1457 | .... | .... | .... | 1324 | 1360 | 1400 |
| | | 20 | .... | .... | 1336 | 1380 | 1430 | 1486 | .... | .... | 1304 | 1339 | 1379 | 1423 |
| | | 22 | .... | .... | 1350 | 1399 | 1454 | 1516 | .... | .... | 1316 | 1354 | 1397 | 1446 |
| | | 24 | .... | .... | 1364 | 1418 | 1478 | 1545 | .... | .... | 1327 | 1369 | 1416 | 1469 |
| | | 26 | .... | .... | 1379 | 1437 | 1502 | 1575 | .... | .... | 1339 | 1384 | 1435 | 1492 |
| | | 28 | .... | .... | 1393 | 1455 | 1526 | 1605 | .... | .... | 1350 | 1398 | 1454 | 1516 |
| | | 30 | .... | .... | 1408 | 1474 | 1550 | .... | .... | .... | 1361 | 1413 | 1473 | 1539 |



# ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## JOINT COMMITTEE RECOMMENDATIONS

$$P = Af_c[1+(n-1)p]$$

*Volume of Hooping = 1% of Volume of Core*

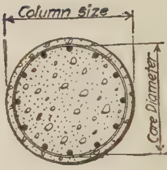
$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{core diameter}}\right) = 10$$

*3000-lb. concrete*
*1:3 mixture*
$n = 10$
$f_c = 1050$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 43 | 39 | 16 | .... | .... | 1370 | 1406 | 1446 | 1491 | .... | .... | .... | 1373 | 1405 | 1440 |
| | | 18 | .... | .... | 1385 | 1424 | 1470 | 1520 | .... | .... | .... | 1388 | 1423 | 1463 |
| | | 20 | .... | .... | 1399 | 1443 | 1494 | 1550 | .... | .... | 1368 | 1403 | 1442 | 1486 |
| | | 22 | .... | .... | 1414 | 1462 | 1517 | 1579 | .... | .... | 1379 | 1418 | 1461 | 1509 |
| | | 24 | .... | .... | 1428 | 1481 | 1541 | 1609 | .... | .... | 1391 | 1432 | 1480 | 1533 |
| | | 26 | .... | .... | 1442 | 1500 | 1565 | 1638 | .... | .... | 1402 | 1447 | 1499 | 1556 |
| | | 28 | .... | .... | 1457 | 1519 | 1589 | 1668 | .... | .... | 1413 | 1462 | 1517 | 1579 |
| | | 30 | .... | .... | 1471 | 1538 | 1613 | 1697 | .... | .... | 1425 | 1477 | 1536 | 1602 |
| 44 | 40 | 16 | .... | .... | .... | 1471 | 1511 | 1556 | .... | .... | .... | 1438 | 1470 | 1505 |
| | | 18 | .... | .... | 1450 | 1490 | 1535 | 1585 | .... | .... | .... | 1453 | 1489 | 1528 |
| | | 20 | .... | .... | 1464 | 1508 | 1559 | 1615 | .... | .... | .... | 1468 | 1507 | 1551 |
| | | 22 | .... | .... | 1479 | 1527 | 1583 | 1644 | .... | .... | 1444 | 1483 | 1526 | 1575 |
| | | 24 | .... | .... | 1493 | 1546 | 1606 | 1674 | .... | .... | 1456 | 1498 | 1545 | 1598 |
| | | 26 | .... | .... | 1508 | 1565 | 1630 | 1703 | .... | .... | 1467 | 1512 | 1564 | 1621 |
| | | 28 | .... | .... | 1522 | 1584 | 1654 | 1733 | .... | .... | 1479 | 1527 | 1582 | 1644 |
| | | 30 | .... | .... | 1536 | 1603 | 1678 | 1762 | .... | .... | 1490 | 1542 | 1601 | 1667 |
| 45 | 41 | 18 | .... | .... | 1517 | 1556 | 1602 | 1652 | .... | .... | .... | 1520 | 1555 | 1595 |
| | | 20 | .... | .... | 1531 | 1575 | 1626 | 1682 | .... | .... | .... | 1535 | 1574 | 1618 |
| | | 22 | .... | .... | 1545 | 1594 | 1649 | 1711 | .... | .... | 1511 | 1550 | 1593 | 1641 |
| | | 24 | .... | .... | 1560 | 1613 | 1673 | 1741 | .... | .... | 1523 | 1564 | 1612 | 1665 |
| | | 26 | .... | .... | 1574 | 1632 | 1697 | 1770 | .... | .... | 1534 | 1579 | 1631 | 1688 |
| | | 28 | .... | .... | 1589 | 1651 | 1721 | 1800 | .... | .... | 1545 | 1594 | 1649 | 1711 |
| | | 30 | .... | .... | 1603 | 1670 | 1745 | 1829 | .... | .... | 1557 | 1609 | 1668 | 1734 |
| 46 | 42 | 18 | .... | .... | .... | 1625 | 1670 | 1720 | .... | .... | .... | 1588 | 1624 | 1663 |
| | | 20 | .... | .... | 1599 | 1644 | 1694 | 1750 | .... | .... | .... | 1603 | 1643 | 1687 |
| | | 22 | | | 1614 | 1663 | 1718 | 1780 | . | .... | .... | 1618 | 1661 | 1710 |
| | | 24 | .... | .... | 1628 | 1681 | 1742 | 1809 | .... | .... | 1591 | 1633 | 1680 | 1733 |
| | | 26 | .... | .... | 1643 | 1700 | 1766 | 1839 | .... | .... | 1602 | 1648 | 1699 | 1756 |
| | | 28 | .... | .... | 1657 | 1719 | 1790 | 1868 | .... | .... | 1614 | 1662 | 1718 | 1779 |
| | | 30 | .... | .... | 1672 | 1738 | 1813 | 1898 | .... | .... | 1625 | 1677 | 1736 | 1803 |
| 47 | 43 | 18 | .... | .... | .... | 1695 | 1740 | 1791 | .... | .... | .... | .... | 1694 | 1734 |
| | | 20 | .... | .... | 1670 | 1714 | 1764 | 1820 | .... | .... | .... | 1673 | 1713 | 1757 |
| | | 22 | .... | .... | 1684 | 1733 | 1788 | 1850 | .... | .... | .... | 1688 | 1731 | 1780 |
| | | 24 | .... | .... | 1698 | 1752 | 1812 | 1879 | .... | .... | .... | 1703 | 1750 | 1803 |
| | | 26 | .... | .... | 1713 | 1771 | 1836 | 1909 | .... | .... | 1673 | 1718 | 1769 | 1826 |
| | | 28 | .... | .... | 1727 | 1789 | 1860 | 1938 | .... | .... | 1684 | 1733 | 1788 | 1850 |
| | | 30 | .... | .... | 1742 | 1808 | 1884 | 1968 | .... | .... | 1695 | 1747 | 1807 | 1873 |
| 48 | 44 | 18 | ... | .... | .... | 1767 | 1812 | 1862 | .... | .... | .... | .... | 1766 | 1805 |
| | | 20 | .... | .... | 1741 | 1786 | 1836 | 1892 | .... | .... | .... | 1745 | 1784 | 1828 |
| | | 22 | .... | .... | 1756 | 1804 | 1860 | 1921 | .... | .... | .... | 1760 | 1803 | 1852 |
| | | 24 | ... | | 1770 | 1823 | 1884 | 1951 | .... | | .... | 1775 | 1822 | 1875 |
| | | 26 | .... | .... | 1785 | 1842 | 1907 | 1980 | .... | .... | 1744 | 1790 | 1841 | 1898 |
| | | 28 | .... | .. | 1799 | 1861 | 1931 | 2010 | .. | .. | 1756 | 1804 | 1860 | 1921 |
| | | 30 | .... | .... | 1814 | 1880 | 1955 | 2039 | .... | .... | 1767 | 1819 | 1879 | 1944 |
| 49 | 45 | 18 | .... | .... | .... | 1840 | 1885 | 1936 | .... | .... | .... | .... | 1839 | 1879 |
| | | 20 | .... | .... | .... | 1859 | 1909 | 1965 | .... | .... | .... | .... | 1858 | 1902 |
| | | 22 | .... | .... | 1829 | 1878 | 1933 | 1995 | .... | .... | .... | 1833 | 1877 | 1925 |
| | | 24 | .... | .... | 1844 | 1897 | 1957 | 2024 | .... | .... | .... | 1848 | 1895 | 1948 |
| | | 26 | .... | . | 1858 | 1916 | 1981 | 2054 | .... | .... | ... | 1863 | 1914 | 1971 |
| | | 28 | .... | .... | 1873 | 1935 | 2005 | 2083 | .... | .... | 1829 | 1878 | 1933 | 1995 |
| | | 30 | .... | .... | 1887 | 1953 | 2029 | 2113 | .... | .... | 1840 | 1893 | 1952 | 2118 |
| 50 | 46 | 20 | .... | .... | .... | 1934 | 1984 | 2040 | .... | .... | .... | .... | 1933 | 1977 |
| | | 22 | .... | .... | 1904 | 1953 | 2008 | 2070 | .... | .... | .... | 1908 | 1952 | 2000 |
| | | 24 | .... | .... | 1919 | 1972 | 2032 | 2099 | . | | .... | 1923 | 1970 | 2023 |
| | | 26 | .... | .... | 1933 | 1991 | 2056 | 2129 | .... | .... | .... | 1938 | 1989 | 2047 |
| | | 28 | .... | .... | 1948 | 2010 | 2080 | 2159 | .... | .... | 1904 | 1953 | 2008 | 2070 |
| | | 30 | .... | .... | 1962 | 2029 | 2104 | 2188 | .... | . | 1915 | 1968 | 2027 | 2093 |

**COLUMNS**

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



***2000-lb. concrete***
***1:6 mixture***
$n = 15$
$f_c = 500$

$$P = Af_c[(1 + 4np') + (n - 1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1 1/ |
| 12 | 8 | 6 | 1¼ | 1 | 6 | 53 |  |  |  |  |  |
| 13 | 9 | 5 | 1½ | 1 | 6 | 64 |  |  |  |  |  |
|  |  |  |  |  | 8 | 68 |  |  |  |  |  |
| 14 | 10 | 4 | 1½ | 1 | 6 | 76 | 81 |  |  |  |  |
|  |  |  |  |  | 8 | 80 |  |  |  |  |  |
| 15 | 11 | 3 | 1⅝ | 1 | 6 | 89 | 95 | 101 |  |  |  |
|  |  |  |  |  | 8 | 93 | 101 |  |  |  |  |
|  |  |  |  |  | 10 | 97 |  |  |  |  |  |
| 16 | 12 | 2 | 1¾ | 1 | 6 | 103 | 109 | 116 |  |  |  |
|  |  |  |  |  | 8 | 108 | 115 |  |  |  |  |
|  |  |  |  |  | 10 | 112 | 121 |  |  |  |  |
|  |  | 3/0 | 1⅝ | 2 | 6 | .... | 143 | 150 |  |  |  |
|  |  |  |  |  | 8 | 142 | 149 |  |  |  |  |
|  |  |  |  |  | 10 | 146 | 155 |  |  |  |  |
| 17 | 13 | 1 | 1¾ | 1 | 6 | 119 | 125 | 131 | 139 |  |  |
|  |  |  |  |  | 8 | 123 | 131 | 140 |  |  |  |
|  |  |  |  |  | 10 | 128 | 137 |  |  |  |  |
|  |  | 4/0 | 1⅞ | 2 | 6 | .... | 165 | 171 | 179 |  |  |
|  |  |  |  |  | 8 | .... | 171 | 180 |  |  |  |
|  |  |  |  |  | 10 | 167 | 177 |  |  |  |  |
| 18 | 14 | 1 | 1¾ | 1 | 6 | 136 | 142 | 148 | 156 |  |  |
|  |  |  |  |  | 8 | 140 | 148 | 157 |  |  |  |
|  |  |  |  |  | 10 | 145 | 154 | 165 |  |  |  |
|  |  |  |  |  | 12 | 149 | 160 |  |  |  |  |
|  |  | 4/0 | 1¾ | 2 | 6 | .... | .... | 195 | 202 |  |  |
|  |  |  |  |  | 8 | .... | 194 | 203 |  |  |  |
|  |  |  |  |  | 10 | 191 | 200 | 211 |  |  |  |
|  |  |  |  |  | 12 | 195 | 206 |  |  |  |  |
| 19 | 15 | 0 | 1⅞ | 1 | 6 | 154 | 160 | 166 | 174 | 183 |  |
|  |  |  |  |  | 8 | 159 | 166 | 175 | 185 |  |  |
|  |  |  |  |  | 10 | 163 | 172 | 183 |  |  |  |
|  |  |  |  |  | 12 | 167 | 178 |  |  |  |  |
|  |  | 5/0 | 1⅞ | 2 | 6 | .... | .... | 220 | 227 | 236 |  |
|  |  |  |  |  | 8 | .... | 219 | 228 | 238 |  |  |
|  |  |  |  |  | 10 | .... | 225 | 236 |  |  |  |
|  |  |  |  |  | 12 | 220 | 231 |  |  |  |  |
| 20 | 16 | 2/0 | 2⅛ | 1 | 8 | 178 | 186 | 195 | 205 | 217 |  |
|  |  |  |  |  | 10 | 182 | 192 | 203 | 216 |  |  |
|  |  |  |  |  | 12 | 187 | 198 | 211 |  |  |  |
|  |  |  |  |  | 14 | 191 | 204 |  |  |  |  |
|  |  | 6/0 | 2 | 2 | 8 | .... | .... | 255 | 265 | 277 |  |
|  |  |  |  |  | 10 | .... | 252 | 263 | 276 |  |  |
|  |  |  |  |  | 12 | .... | 258 | 272 |  |  |  |
|  |  |  |  |  | 14 | 251 | 265 |  |  |  |  |

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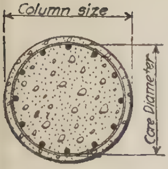

$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right)=15$$

*2000-lb. concrete*
*1:6 mixture*
$n=15$
$f_c=500$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 21 | 17 | 2/0 | 2 | 1 | 8 | 199 | 206 | 215 | 226 | 237 | |
| | | | | | 10 | 203 | 213 | 224 | 237 | | |
| | | | | | 12 | 207 | 219 | 232 | | | |
| | | | | | 14 | 212 | 225 | 241 | | | |
| | | 6/0 | 1⅞ | 2 | 8 | .... | .... | 283 | 294 | 305 | |
| | | | | | 10 | .... | .... | 292 | 305 | | |
| | | | | | 12 | .... | 287 | 300 | | | |
| | | | | | 14 | .... | 293 | 309 | | | |
| 22 | 18 | 3/0 | 2¼ | 1 | 8 | .... | 228 | 237 | 248 | 259 | 272 |
| | | | | | 10 | 225 | 235 | 246 | 259 | 273 | |
| | | | | | 12 | 229 | 241 | 254 | 270 | | |
| | | | | | 14 | 234 | 247 | 263 | | | |
| | | 7/0 | 2 | 2 | 8 | .... | .... | .... | 324 | 336 | 349 |
| | | | | | 10 | .... | .... | 322 | 335 | 350 | |
| | | | | | 12 | .... | 317 | 330 | 346 | | |
| | | | | | 14 | .... | 323 | 339 | | | |
| 23 | 19 | 3/0 | 2⅛ | 1 | 8 | .... | 252 | 260 | 271 | 282 | 296 |
| | | | | | 10 | 248 | 258 | 269 | 282 | 296 | |
| | | | | | 12 | 253 | 264 | 277 | 293 | | |
| | | | | | 14 | 257 | 270 | 286 | 304 | | |
| | | | | | 16 | 261 | 276 | 294 | | | |
| | | 7/0 | 1⅞ | 2 | 8 | .... | .... | .... | 356 | 368 | 381 |
| | | | | | 10 | .... | .... | 354 | 367 | 381 | |
| | | | | | 12 | .... | .... | 362 | 378 | | |
| | | | | | 14 | .... | 355 | 370 | 389 | | |
| | | | | | 16 | .... | 361 | 379 | | | |
| 24 | 20 | 3/0 | 2 | 1 | 8 | .... | 276 | 285 | 295 | 307 | 320 |
| | | | | | 10 | .... | 282 | 293 | 306 | 321 | 337 |
| | | | | | 12 | 277 | 288 | 302 | 317 | 335 | |
| | | | | | 14 | 281 | 295 | 310 | 328 | | |
| | | | | | 16 | 286 | 301 | 319 | 339 | | |
| | | 7/0 | 1⅞ | 2 | 8 | .... | .... | .... | 390 | 401 | 414 |
| | | | | | 10 | .... | .... | .... | 401 | 415 | 432 |
| | | | | | 12 | .... | .... | 396 | 412 | 429 | |
| | | | | | 14 | .... | .... | 405 | 423 | | |
| | | | | | 16 | ... | 395 | 413 | 434 | | |
| 25 | 21 | 4/0 | 2¼ | 1 | 10 | .... | 308 | 319 | 332 | 347 | 363 |
| | | | | | 12 | 303 | 314 | 328 | 343 | 361 | |
| | | | | | 14 | 307 | 320 | 336 | 354 | | |
| | | | | | 16 | 311 | 327 | 344 | 365 | | |
| | | 7/0 | 1¾ | 2 | 10 | .... | .... | .... | 436 | 451 | 467 |
| | | | | | 12 | .... | .... | 432 | 447 | 465 | |
| | | | | | 14 | .... | .... | 440 | 458 | | |
| | | | | | 16 | .... | 430 | 448 | 469 | | |

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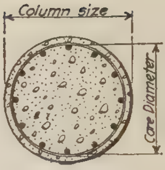

*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 500$

$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 26 | 22 | 4/0 | 2 1/8 | 1 | 10 | .... | 335 | 346 | 359 | 374 | 390 |
|  |  |  |  |  | 12 | .... | 341 | 355 | 370 | 387 | 407 |
|  |  |  |  |  | 14 | 334 | 347 | 363 | 381 | 401 |  |
|  |  |  |  |  | 16 | 338 | 354 | 371 | 392 |  |  |
|  |  |  |  |  | 18 | 343 | 360 | 380 | 403 |  |  |
|  |  | 7/0 | 1 5/8 | 2 | 10 | .... | .... | .... | 473 | 488 | 504 |
|  |  |  |  |  | 12 | .... | .... | .... | 484 | 502 | 521 |
|  |  |  |  |  | 14 | .... | .... | 477 | 495 | 516 |  |
|  |  |  |  |  | 16 |  | .... | 485 | 506 |  |  |
|  |  |  |  |  | 18 | .... | 474 | 494 | 517 |  |  |
| 27 | 23 | 4/0 | 2 1/8 | 1 | 10 | .... | 363 | 374 | 387 | 402 | 418 |
|  |  |  |  |  | 12 | .... | 370 | 383 | 398 | 416 | 435 |
|  |  |  |  |  | 14 | 362 | 376 | 391 | 409 | 430 |  |
|  |  |  |  |  | 16 | 367 | 382 | 400 | 420 | 444 |  |
|  |  |  |  |  | 18 | 371 | 388 | 408 | 431 |  |  |
|  |  | 7/0 | 1 5/8 | 2 | 10 |  | .... |  | .... | 527 | 543 |
|  |  |  |  |  | 12 |  | .... | .... | 523 | 540 | 560 |
|  |  |  |  |  | 14 | .... | .... | 516 | 534 | 554 |  |
|  |  |  |  |  | 16 | .... | .... | 524 | 545 | 568 |  |
|  |  |  |  |  | 18 | .... | .... | 533 | 556 |  |  |
| 28 | 24 | 4/0 | 2 | 1 | 10 | .... | .... | 404 | 417 | 431 | 448 |
|  |  |  |  |  | 12 | .... | 399 | 412 | 428 | 445 | 465 |
|  |  |  |  |  | 14 | .... | 405 | 421 | 439 | 459 | 482 |
|  |  |  |  |  | 16 | 396 | 411 | 429 | 450 | 473 |  |
|  |  |  |  |  | 18 | 401 | 418 | 438 | 461 | 487 |  |
|  |  | 7/0 | 1 1/2 | 2 | 10 | .... | .... | .... | .... | 567 | 584 |
|  |  |  |  |  | 12 | .... | .... | .... | 564 | 581 | 601 |
|  |  |  |  |  | 14 | .... | .... | .... | 575 | 595 | 618 |
|  |  |  |  |  | 16 | .... | .... | 565 | 586 | 609 |  |
|  |  |  |  |  | 18 |  | .... | 573 | 597 | 623 |  |
| 29 | 25 | 5/0 | 2 1/4 | 1 | 10 | .... | .... | 435 | 448 | 462 | 479 |
|  |  |  |  |  | 12 | .... | 430 | 443 | 459 | 476 | 496 |
|  |  |  |  |  | 14 | .... | 436 | 452 | 470 | 490 | 513 |
|  |  |  |  |  | 16 | 427 | 442 | 460 | 481 | 504 | 530 |
|  |  |  |  |  | 18 | 431 | 448 | 468 | 492 |  |  |
|  |  |  |  |  | 20 | 436 | 455 | 477 | 504 |  |  |
|  |  | 7/0 | 1 1/2 | 2 | 10 | .... | .... | .... | .... | 609 | 626 |
|  |  |  |  |  | 12 | .... | .... | .... | .... | 623 | 643 |
|  |  |  |  |  | 14 |  | .... | .... | 617 | 637 | 660 |
|  |  |  |  |  | 16 |  | .... | .... | 628 | 651 | 677 |
|  |  |  |  |  | 18 |  | .... | 616 | 639 | 665 |  |
|  |  |  |  |  | 20 |  | .... | 624 | 650 |  |  |
| 30 | 26 | 5/0 | 2 1/4 | 1 | 12 |  | 462 | 475 | 491 | 508 | 528 |
|  |  |  |  |  | 14 | .... | 468 | 484 | 502 | 522 | 545 |
|  |  |  |  |  | 16 | .... | 474 | 492 | 513 | 536 | 562 |
|  |  |  |  |  | 18 | 463 | 480 | 500 | 524 | 550 |  |
|  |  |  |  |  | 20 | 468 | 487 | 509 | 535 | 564 |  |
|  |  | 7/0 | 1 1/2 | 1.93 | 12 | .... | .... | .... | .... | 656 | 676 |
|  |  |  |  |  | 14 | .... | .... | .... | 650 | 670 | 693 |
|  |  |  |  |  | 16 | .... | .... | .... | 661 | 684 | 710 |
|  |  |  |  |  | 18 | .... | .... | 649 | 672 | 698 |  |
|  |  |  |  |  | 20 | .... | .... | 657 | 683 | 712 |  |

TABLE 35

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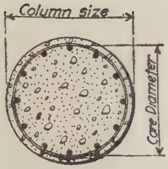

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$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 31 | 27 | 5/0 | 2⅛ | 1 | 12 | .... | .... | 509 | 524 | 542 | 561 |
| | | | | | 14 | .... | 501 | 517 | 535 | 555 | 578 |
| | | | | | 16 | .... | 508 | 525 | 546 | 569 | 595 |
| | | | | | 18 | .... | 514 | 534 | 557 | 583 | 613 |
| | | | | | 20 | 501 | 520 | 542 | 568 | 597 | |
| | | | | | 22 | 505 | 526 | 550 | 579 | 611 | |
| | | 7/0 | 1½ | 1.86 | 12 | .... | .... | .... | .... | 689 | 709 |
| | | | | | 14 | .... | .... | .... | 683 | 703 | 726 |
| | | | | | 16 | .... | .... | .... | 694 | 717 | 743 |
| | | | | | 18 | .... | .... | 682 | 705 | 731 | 760 |
| | | | | | 20 | .... | .... | 690 | 716 | 745 | |
| | | | | | 22 | .... | .... | 698 | 727 | 759 | |
| 32 | 28 | 5/0 | 2 | 1 | 12 | .... | .... | 543 | 559 | 576 | 596 |
| | | | | | 14 | .... | 536 | 552 | 570 | 590 | 613 |
| | | | | | 16 | .... | 542 | 560 | 581 | 604 | 630 |
| | | | | | 18 | .... | 548 | 568 | 592 | 618 | 647 |
| | | | | | 20 | .... | 554 | 577 | 603 | 632 | 664 |
| | | | | | 22 | 540 | 561 | 585 | 614 | 646 | |
| | | 7/0 | 1½ | 1.80 | 12 | .... | .... | .... | .... | 723 | 743 |
| | | | | | 14 | .... | .... | .... | 717 | 737 | 760 |
| | | | | | 16 | .... | .... | .... | 728 | 751 | 777 |
| | | | | | 18 | .... | .... | .... | 739 | 765 | 795 |
| | | | | | 20 | .... | .... | 724 | 750 | 779 | 812 |
| | | | | | 22 | .... | .... | 733 | 761 | 793 | 829 |
| 33 | 29 | 6/0 | 2¼ | 1 | 12 | .... | .... | 579 | 594 | 612 | 631 |
| | | | | | 14 | .... | .... | 587 | 605 | 626 | 649 |
| | | | | | 16 | .... | 578 | 596 | 616 | 640 | 666 |
| | | | | | 18 | .... | 584 | 604 | 627 | 654 | 683 |
| | | | | | 20 | .... | 590 | 613 | 638 | 668 | 700 |
| | | | | | 22 | 576 | 596 | 621 | 649 | 681 | |
| | | 7/0 | 1½ | 1.73 | 12 | .... | .... | .... | .... | 756 | 776 |
| | | | | | 14 | .... | .... | .... | .... | 770 | 793 |
| | | | | | 16 | .... | .... | .... | 761 | 784 | 810 |
| | | | | | 18 | .... | .... | .... | 772 | 798 | 828 |
| | | | | | 20 | .... | .... | 757 | 783 | 812 | 845 |
| | | | | | 22 | .... | .... | 765 | 794 | 826 | |
| 34 | 30 | 6/0 | 2¼ | 1 | 12 | .... | .... | 616 | 631 | 649 | 669 |
| | | | | | 14 | .... | .... | 624 | 642 | 663 | 686 |
| | | | | | 16 | .... | 615 | 633 | 653 | 677 | 703 |
| | | | | | 18 | .... | 621 | 641 | 664 | 691 | 720 |
| | | | | | 20 | .... | 627 | 650 | 675 | 705 | 737 |
| | | | | | 22 | .... | 634 | 658 | 686 | 719 | 755 |
| | | | | | 24 | 617 | 640 | 667 | 697 | 733 | |
| | | 7/0 | 1½ | 1.67 | 12 | .... | .... | .... | .... | 791 | 811 |
| | | | | | 14 | .... | | | .... | 805 | 828 |
| | | | | | 16 | .... | | | 796 | 819 | 845 |
| | | | | | 18 | | | | 807 | 833 | 862 |
| | | | | | 20 | | | 792 | 818 | 847 | 879 |
| | | | | | 22 | | | 800 | 829 | 861 | 897 |
| | | | | | 24 | . | | 809 | 840 | 875 | |

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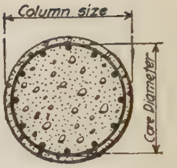


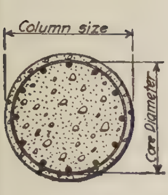
***2000-lb. concrete***
***1:6 mixture***
$n = 15$
$f_c = 500$

$$P = Af_c[(1+4np') + (n-1)p]$$

$$Max. \left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 35 | 31 | 6/0 | 2⅛ | 1 | 14 | .... | .... | 662 | 680 | 701 | 724 |
|  |  |  |  |  | 16 | .... | .... | 671 | 691 | 715 | 741 |
|  |  |  |  |  | 18 | .... | 659 | 679 | 702 | 729 | 758 |
|  |  |  |  |  | 20 | .... | 665 | 687 | 713 | 742 | 774 |
|  |  |  |  |  | 22 | .... | 671 | 696 | 724 | 756 | 792 |
|  |  |  |  |  | 24 | .... | 678 | 704 | 735 | 770 | 710 |
|  |  | 7/0 | 1½ | 1.62 | 14 | .... | .... | .... | .... | 842 | 864 |
|  |  |  |  |  | 16 | .... | .... | .... | 832 | 856 | 882 |
|  |  |  |  |  | 18 | .... | .... | .... | 843 | 869 | 899 |
|  |  |  |  |  | 20 | .... | .... | .... | 854 | 883 | 916 |
|  |  |  |  |  | 22 | .... | .... | 837 | 865 | 897 | 933 |
|  |  |  |  |  | 24 | .... | .... | 845 | 876 | 971 | 950 |
| 36 | 32 | 6/0 | 2 | 1 | 14 | .... | .... | 702 | 720 | 741 | 764 |
|  |  |  |  |  | 16 | .... | .... | 711 | 731 | 755 | 781 |
|  |  |  |  |  | 18 | .... | .... | 719 | 742 | 769 | 798 |
|  |  |  |  |  | 20 | .... | 705 | 728 | 753 | 783 | 815 |
|  |  |  |  |  | 22 | .... | 711 | 736 | 764 | 796 | 832 |
|  |  |  |  |  | 24 | .... | 718 | 744 | 775 | 810 | 850 |
|  |  | 7/0 | 1½ | 1.57 | 14 | .... | .... | .... | .... | 878 | 901 |
|  |  |  |  |  | 16 | .... | .... | .... | 869 | 892 | 918 |
|  |  |  |  |  | 18 | .... | .... | .... | 880 | 906 | 935 |
|  |  |  |  |  | 20 | .... | .... | .... | 891 | 920 | 953 |
|  |  |  |  |  | 22 | .... | .... | 873 | 902 | 934 | 970 |
|  |  |  |  |  | 24 | .... | .... | 881 | 913 | 948 | 987 |
| 37 | 33 | 7/0 | 2¼ | 1 | 14 | .... | .... | .... | 761 | 782 | 805 |
|  |  |  |  |  | 16 | .... | .... | 752 | 772 | 796 | 822 |
|  |  |  |  |  | 18 | .... | .... | 760 | 783 | 809 | 839 |
|  |  |  |  |  | 20 | .... | 746 | 768 | 794 | 823 | 856 |
|  |  |  |  |  | 22 | .... | 752 | 777 | 805 | 837 | 873 |
|  |  |  |  |  | 24 | .... | 758 | 785 | 816 | 851 | 890 |
|  |  |  |  |  | 26 | .... | 765 | 794 | 827 | 865 | 908 |
|  |  | 7/0 | 1½ | 1.52 | 14 | .... | .... | .... | .... | 915 | 938 |
|  |  |  |  |  | 16 | .... | .... | .... | .... | 929 | 955 |
|  |  |  |  |  | 18 | .... | .... | .... | 917 | 943 | 972 |
|  |  |  |  |  | 20 | .... | .... | .... | 928 | 957 | 989 |
|  |  |  |  |  | 22 | .... | .... | 910 | 939 | 971 | 1007 |
|  |  |  |  |  | 24 | .... | .... | 919 | 950 | 985 | 1024 |
|  |  |  |  |  | 26 | .... | .... | 927 | 961 | 999 | 1041 |
| 38 | 34 | 7/0 | 2⅛ | 1 | 14 | .... | .... | .... | 803 | 824 | 847 |
|  |  |  |  |  | 16 | .... | .... | 794 | 814 | 838 | 864 |
|  |  |  |  |  | 18 | .... | .... | 802 | 825 | 852 | 881 |
|  |  |  |  |  | 20 | .... | .... | 810 | 836 | 865 | 898 |
|  |  |  |  |  | 22 | .... | 794 | 819 | 847 | 879 | 915 |
|  |  |  |  |  | 24 | .... | 801 | 827 | 858 | 893 | 932 |
|  |  |  |  |  | 26 | .... | 807 | 836 | 869 | 907 | 950 |
|  |  | 7/0 | 1½ | 1.48 | 14 | .... | .... | .... | .... | 954 | 977 |
|  |  |  |  |  | 16 | .... | .... | .... | .... | 968 | 994 |
|  |  |  |  |  | 18 | .... | .... | .... | 956 | 982 | 1012 |
|  |  |  |  |  | 20 | .... | .... | .... | 967 | 996 | 1029 |
|  |  |  |  |  | 22 | .... | .... | .... | 978 | 1010 | 1046 |
|  |  |  |  |  | 24 | .... | .... | 958 | 989 | 1024 | 1063 |
|  |  |  |  |  | 26 | .... | .... | 966 | 1000 | 1038 | 1080 |

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



$$P = Af_c[(1+4np')+(n-1)p]$$

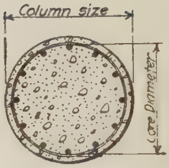
$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 39 | 35 | 7/0 | 2⅛ | 1 | 14 | .... | .... | .... | 847 | 867 | 890 |
| | | | | | 16 | .... | .... | .... | 858 | 881 | 907 |
| | | | | | 18 | .... | .... | 845 | 869 | 895 | 924 |
| | | | | | 20 | .... | .... | 854 | 880 | 909 | 941 |
| | | | | | 22 | .... | .... | 862 | 891 | 923 | 959 |
| | | | | | 24 | .... | 844 | 871 | 902 | 937 | 976 |
| | | | | | 26 | .... | 850 | 879 | 913 | 951 | 993 |
| | | 7/0 | 1½ | 1.43 | 14 | .... | .... | .... | .... | 991 | 1014 |
| | | | | | 16 | .... | .... | .... | .... | 1005 | 1031 |
| | | | | | 18 | .... | .... | .... | 993 | 1019 | 1048 |
| | | | | | 20 | .... | .... | .... | 1004 | 1033 | 1066 |
| | | | | | 22 | .... | .... | .... | 1015 | 1047 | 1083 |
| | | | | | 24 | .... | .... | 995 | 1026 | 1061 | 1100 |
| | | | | | 26 | .... | .... | 1003 | 1037 | 1075 | 1117 |
| 40 | 36 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 902 | 926 | 952 |
| | | | | | 18 | .... | .... | .... | 913 | 940 | 969 |
| | | | | | 20 | .... | .... | 899 | 924 | 953 | 986 |
| | | | | | 22 | .... | .... | 907 | 935 | 967 | 1003 |
| | | | | | 24 | .... | .... | 915 | 946 | 981 | 1020 |
| | | | | | 26 | .... | 895 | 924 | 957 | 995 | 1038 |
| | | | | | 28 | .... | 901 | 932 | 968 | 1009 | 1055 |
| | | 7/0 | 1½ | 1.40 | 16 | .... | .... | .... | .... | 1048 | 1074 |
| | | | | | 18 | .... | .... | .... | .... | 1062 | 1091 |
| | | | | | 20 | .... | .... | .... | 1046 | 1076 | 1108 |
| | | | | | 22 | .... | .... | .... | 1057 | 1089 | 1125 |
| | | | | | 24 | .... | .... | 1037 | 1068 | 1103 | 1143 |
| | | | | | 26 | .... | .... | 1046 | 1079 | 1117 | 1160 |
| | | | | | 28 | .... | .... | 1054 | 1090 | 1131 | 1177 |
| 41 | 37 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 948 | 971 | 998 |
| | | | | | 18 | .... | .... | 936 | 959 | 985 | 1015 |
| | | | | | 20 | .... | .... | 944 | 970 | 999 | 1032 |
| | | | | | 22 | .... | .... | 953 | 981 | 1013 | 1049 |
| | | | | | 24 | .... | 934 | 961 | 992 | 1027 | 1066 |
| | | | | | 26 | .... | 941 | 970 | 1003 | 1041 | 1083 |
| | | | | | 28 | .... | 947 | 978 | 1014 | 1055 | 1101 |
| | | 7/0 | 1½ | 1.36 | 16 | .... | .... | .... | .... | 1088 | 1114 |
| | | | | | 18 | .... | .... | .... | .... | 1101 | 1131 |
| | | | | | 20 | .... | .... | .... | 1086 | 1115 | 1148 |
| | | | | | 22 | .... | .... | .... | 1097 | 1129 | 1165 |
| | | | | | 24 | .... | .... | .... | 1108 | 1143 | 1182 |
| | | | | | 26 | .... | .... | 1086 | 1119 | 1157 | 1200 |
| | | | | | 28 | .... | .... | 1094 | 1130 | 1171 | 1217 |

TABLE 35

# ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



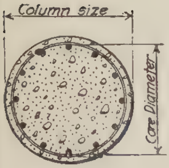
*2000-lb. concrete*
*1:6 mixture*
$n = 15$
$f_c = 500$

$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals: Size No. (A. S. & W. Co.) | Spirals: Pitch (inches) | Spirals: Per cent of core | Number of rods | Size of vertical round rods: 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 42 | 38 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 995 | 1019 | 1045 |
| | | | | | 18 | .... | .... | .... | 1006 | 1032 | 1062 |
| | | | | | 20 | .... | .... | 991 | 1017 | 1046 | 1079 |
| | | | | | 22 | .... | .... | 1000 | 1028 | 1060 | 1096 |
| | | | | | 24 | .... | .... | 1008 | 1039 | 1074 | 1113 |
| | | | | | 26 | .... | 988 | 1017 | 1050 | 1088 | 1131 |
| | | | | | 28 | .... | 994 | 1025 | 1061 | 1102 | 1148 |
| | | | | | 30 | .... | 1000 | 1033 | 1072 | 1116 | 1165 |
| | | 7/0 | 1 1/2 | 1.32 | 16 | .... | .... | .... | .... | 1127 | 1154 |
| | | | | | 18 | .... | .... | .... | .... | 1141 | 1170 |
| | | | | | 20 | .... | .... | .... | 1126 | 1155 | 1188 |
| | | | | | 22 | .... | .... | .... | 1137 | 1169 | 1205 |
| | | | | | 24 | .... | .... | .... | 1148 | 1183 | 1222 |
| | | | | | 26 | .... | .... | 1126 | 1159 | 1197 | 1239 |
| | | | | | 28 | .... | .... | 1134 | 1170 | 1211 | 1257 |
| | | | | | 30 | .... | .... | 1142 | 1181 | 1225 | 1274 |
| 43 | 39 | 7/0 | 1 7/8 | 1 | 16 | .... | .... | .... | 1044 | 1067 | 1093 |
| | | | | | 18 | .... | .... | .... | 1055 | 1081 | 1110 |
| | | | | | 20 | .... | .... | 1040 | 1066 | 1095 | 1127 |
| | | | | | 22 | .... | .... | 1048 | 1077 | 1109 | 1145 |
| | | | | | 24 | .... | .... | 1057 | 1088 | 1123 | 1162 |
| | | | | | 26 | .... | .... | 1065 | 1099 | 1137 | 1179 |
| | | | | | 28 | .... | 1042 | 1073 | 1110 | 1151 | 1196 |
| | | | | | 30 | .... | 1048 | 1082 | 1121 | 1164 | 1213 |
| | | 7/0 | 1 1/2 | 1.29 | 16 | .... | .... | .... | .... | 1171 | 1197 |
| | | | | | 18 | .... | .... | .... | .... | 1185 | 1214 |
| | | | | | 20 | .... | .... | .... | 1170 | 1199 | 1231 |
| | | | | | 22 | .... | .... | .... | 1181 | 1213 | 1249 |
| | | | | | 24 | .... | .... | .... | 1192 | 1227 | 1266 |
| | | | | | 26 | .... | .... | 1169 | 1203 | 1241 | 1283 |
| | | | | | 28 | .... | .... | 1177 | 1214 | 1254 | 1300 |
| | | | | | 30 | .... | .... | 1186 | 1225 | 1268 | 1317 |
| 44 | 40 | 7/0 | 1 7/8 | 1 | 16 | .... | .... | .... | 1093 | 1117 | 1143 |
| | | | | | 18 | .... | .... | .... | 1104 | 1130 | 1160 |
| | | | | | 20 | .... | .... | .... | 1115 | 1144 | 1177 |
| | | | | | 22 | .... | .... | 1098 | 1126 | 1158 | 1194 |
| | | | | | 24 | .... | .... | 1106 | 1137 | 1172 | 1211 |
| | | | | | 26 | .... | .... | 1115 | 1148 | 1186 | 1229 |
| | | | | | 28 | .... | 1092 | 1123 | 1159 | 1200 | 1246 |
| | | | | | 30 | .... | 1098 | 1132 | 1170 | 1214 | 1263 |
| | | 7/0 | 1 1/2 | 1.25 | 16 | .... | .... | .... | .... | 1211 | 1237 |
| | | | | | 18 | .... | .... | .... | .... | 1225 | 1254 |
| | | | | | 20 | .... | .... | .... | 1209 | 1239 | 1271 |
| | | | | | 22 | .... | .... | .... | 1220 | 1253 | 1288 |
| | | | | | 24 | .... | .... | .... | 1231 | 1266 | 1306 |
| | | | | | 26 | .... | .... | .... | 1242 | 1280 | 1323 |
| | | | | | 28 | .... | .... | 1217 | 1253 | 1294 | 1340 |
| | | | | | 30 | .... | .... | 1226 | 1264 | 1308 | 1357 |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



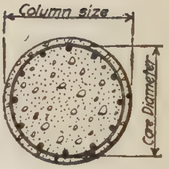
$$P = Af_c[(1+4np') + (n-1)p]$$

$$Max.\left(\frac{unsupported\ length}{diameter}\right) = 15$$

*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 625$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 8 | 6 | 1¼ | 1 | 6 | 59 | | | | | |
| 13 | 9 | 5 | 1½ | 1 | 6 | 71 | | | | | |
| | | | | | 8 | 76 | | | | | |
| 14 | 10 | 4 | 1½ | 1 | 6 | 85 | 91 | | | | |
| | | | | | 8 | 89 | | | | | |
| 15 | 11 | 3 | 1⅝ | 1 | 6 | 100 | 106 | 113 | | | |
| | | | | | 8 | 105 | 112 | | | | |
| | | | | | 10 | 109 | | | | | |
| 16 | 12 | 2 | 1¾ | 1 | 6 | 117 | 123 | 129 | | | |
| | | | | | 8 | 121 | 129 | | | | |
| | | | | | 10 | 126 | 135 | | | | |
| | | 3/0 | 1⅝ | 2 | 6 | .... | 157 | 163 | | | |
| | | | | | 8 | 155 | 163 | | | | |
| | | | | | 10 | 160 | 169 | | | | |
| 17 | 13 | 1 | 1¾ | 1 | 6 | 135 | 141 | 148 | | | |
| | | | | | 8 | 140 | 147 | 156 | | | |
| | | | | | 10 | 144 | 153 | | | | |
| | | 4/0 | 1⅞ | 2 | 6 | .... | 181 | 187 | 195 | | |
| | | | | | 8 | .... | 187 | 196 | | | |
| | | | | | 10 | 184 | 193 | | | | |
| 18 | 14 | 1 | 1¾ | 1 | 6 | 155 | 161 | 167 | 175 | | |
| | | | | | 8 | 159 | 167 | 175 | | | |
| | | | | | 10 | 163 | 173 | 184 | | | |
| | | | | | 12 | 168 | 179 | | | | |
| | | 4/0 | 1¾ | 2 | 6 | .... | .... | 213 | 221 | | |
| | | | | | 8 | .... | 213 | 222 | | | |
| | | | | | 10 | 210 | 219 | 230 | | | |
| | | | | | 12 | 214 | 225 | | | | |
| 19 | 15 | 0 | 1⅞ | 1 | 6 | 176 | 182 | 188 | 196 | 204 | |
| | | | | | 8 | 180 | 188 | 196 | 207 | | |
| | | | | | 10 | 184 | 194 | 205 | | | |
| | | | | | 12 | 189 | 200 | | | | |
| | | 5/0 | 1⅞ | 2 | 6 | .... | .... | 241 | 249 | 258 | |
| | | | | | 8 | .... | 241 | 250 | 260 | | |
| | | | | | 10 | .... | 247 | 258 | | | |
| | | | | | 12 | 242 | 253 | | | | |
| 20 | 16 | 2/0 | 2⅛ | 1 | 8 | 203 | 210 | 219 | 229 | 241 | |
| | | | | | 10 | 207 | 216 | 227 | 240 | | |
| | | | | | 12 | 211 | 222 | 236 | | | |
| | | | | | 14 | 216 | 229 | | | | |
| | | 6/0 | 2 | 2 | 8 | .... | .... | 279 | 289 | 301 | |
| | | | | | 10 | .... | 277 | 288 | 300 | | |
| | | | | | 12 | .... | 283 | 296 | | | |
| | | | | | 14 | 276 | 289 | | | | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 625$

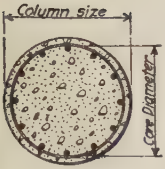
$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 21 | 17 | 2/0 | 2 | 1 | 8 | 227 | 234 | 243 | 253 | 265 | |
| | | | | | 10 | 231 | 240 | 251 | 264 | | |
| | | | | | 12 | 235 | 246 | 260 | | | |
| | | | | | 14 | 240 | 253 | 268 | | | |
| | | 6/0 | 1⅞ | 2 | 8 | .... | .... | 311 | 321 | 333 | |
| | | | | | 10 | .... | .... | 319 | 332 | | |
| | | | | | 12 | .... | 314 | 328 | | | |
| | | | | | 14 | .... | 321 | 336 | | | |
| 22 | 18 | 3/0 | 2¼ | 1 | 8 | .... | 260 | 268 | 279 | 290 | 303 |
| | | | | | 10 | 257 | 266 | 277 | 289 | 304 | |
| | | | | | 12 | 261 | 272 | 285 | 300 | | |
| | | | | | 14 | 265 | 278 | 293 | | | |
| | | 7/0 | 2 | 2 | 8 | .... | .... | .... | 355 | 366 | 379 |
| | | | | | 10 | .... | .... | 353 | 366 | 380 | |
| | | | | | 12 | .... | 348 | 361 | 377 | | |
| | | | | | 14 | .... | 354 | 370 | | | |
| 23 | 19 | 3/0 | 2⅛ | 1 | 8 | .... | 286 | 295 | 305 | 317 | 330 |
| | | | | | 10 | 283 | 293 | 304 | 316 | 331 | |
| | | | | | 12 | 288 | 299 | 312 | 327 | | |
| | | | | | 14 | 292 | 305 | 320 | 338 | | |
| | | | | | 16 | 296 | 311 | 328 | | | |
| | | 7/0 | 1⅞ | 2 | 8 | .... | .... | .... | 391 | 402 | 415 |
| | | | | | 10 | .... | .... | 389 | 401 | 416 | |
| | | | | | 12 | .... | .... | 397 | 412 | | |
| | | | | | 14 | .... | 390 | 405 | 423 | | |
| | | | | | 16 | .... | 396 | 414 | | | |
| 24 | 20 | 3/0 | 2 | 1 | 8 | | 315 | 324 | 334 | 345 | 358 |
| | | | | | 10 | .... | 321 | 332 | 345 | 359 | 375 |
| | | | | | 12 | 316 | 327 | 340 | 355 | 373 | |
| | | | | | 14 | 320 | 333 | 348 | 366 | | |
| | | | | | 16 | 324 | 339 | 357 | 377 | | |
| | | 7/0 | 1⅞ | 2 | 8 | .... | .... | .... | 428 | 440 | 452 |
| | | | | | 10 | .... | .... | .... | 439 | 453 | 469 |
| | | | | | 12 | .... | .... | 435 | 450 | 467 | |
| | | | | | 14 | .... | .... | 443 | 461 | | |
| | | | | | 16 | .... | 434 | 451 | 471 | | |
| 25 | 21 | 4/0 | 2¼ | 1 | 10 | .... | 350 | 361 | 374 | 388 | 404 |
| | | | | | 12 | 345 | 356 | 369 | 385 | 402 | |
| | | | | | 14 | 349 | 362 | 378 | 395 | | |
| | | | | | 16 | 354 | 368 | 386 | 406 | | |
| | | 7/0 | 1¾ | 2 | 10 | .... | .... | .... | 478 | 492 | 508 |
| | | | | | 12 | .... | .... | 474 | 489 | 506 | |
| | | | | | 14 | .... | .... | 482 | 500 | | |
| | | | | | 16 | .... | 473 | 490 | 510 | | |

TABLE 36

## ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



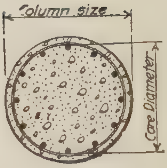
$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 625$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 26 | 22 | 4/0 | 2⅛ | 1 | 10 | .... | 382 | 393 | 405 | 420 | 435 |
| | | | | | 12 | .... | 388 | 401 | 416 | 433 | 453 |
| | | | | | 14 | 381 | 394 | 409 | 427 | 447 | |
| | | | | | 16 | 385 | 400 | 418 | 438 | | |
| | | | | | 18 | 389 | 406 | 426 | 449 | | |
| | | 7/0 | 1⅝ | 2 | 10 | .... | .... | .... | 520 | 534 | 550 |
| | | | | | 12 | .... | .... | .... | 531 | 548 | 567 |
| | | | | | 14 | .... | .... | 524 | 542 | 562 | |
| | | | | | 16 | .... | .... | 532 | 552 | | |
| | | | | | 18 | .... | 521 | 540 | 563 | | |
| 27 | 23 | 4/0 | 2⅛ | 1 | 10 | .... | 414 | 425 | 438 | 452 | 468 |
| | | | | | 12 | .... | 420 | 434 | 449 | 466 | 485 |
| | | | | | 14 | 414 | 427 | 442 | 460 | 480 | |
| | | | | | 16 | 418 | 433 | 450 | 470 | 493 | |
| | | | | | 18 | 422 | 439 | 458 | 481 | | |
| | | 7/0 | 1⅝ | 2 | 10 | .... | .... | .... | .... | 576 | 592 |
| | | | | | 12 | .... | .... | .... | 573 | 590 | 609 |
| | | | | | 14 | .... | .... | 566 | 584 | 604 | |
| | | | | | 16 | .... | .... | 574 | 594 | 617 | |
| | | | | | 18 | .... | .... | 582 | 605 | | |
| 28 | 24 | 4/0 | 2 | 1 | 10 | .... | .... | 460 | 472 | 487 | 503 |
| | | | | | 12 | .... | 455 | 468 | 483 | 500 | 519 |
| | | | | | 14 | .... | 461 | 476 | 494 | 514 | 536 |
| | | | | | 16 | 452 | 467 | 484 | 505 | 527 | |
| | | | | | 18 | 456 | 473 | 493 | 515 | 541 | |
| | | 7/0 | 1½ | 2 | 10 | .... | .... | .... | .... | 623 | 639 |
| | | | | | 12 | .... | .... | .... | 619 | 637 | 656 |
| | | | | | 14 | .... | .... | .... | 630 | 650 | 673 |
| | | | | | 16 | .... | .... | 621 | 641 | 664 | |
| | | | | | 18 | .... | .... | 629 | 652 | 678 | |
| 29 | 25 | 5/0 | 2¼ | 1 | 10 | .... | .... | 495 | 508 | 522 | |
| | | | | | 12 | .... | 490 | 503 | 519 | 536 | |
| | | | | | 14 | .... | 496 | 512 | 529 | 549 | |
| | | | | | 16 | 487 | 502 | 520 | 540 | 563 | |
| | | | | | 18 | 492 | 508 | 528 | 551 | 577 | |
| | | | | | 20 | 496 | 514 | 537 | 562 | | |
| | | 7/0 | 1½ | 2 | 10 | .... | .... | .... | .... | 670 | 686 |
| | | | | | 12 | .... | .... | .... | .... | 683 | 703 |
| | | | | | 14 | .... | .... | .... | 677 | 697 | 719 |
| | | | | | 16 | .... | .... | .... | 688 | 711 | 736 |
| | | | | | 18 | .... | .... | 676 | 699 | 724 | |
| | | | | | 20 | .... | .... | 684 | 709 | | |
| 30 | 26 | 5/0 | 2¼ | 1 | 12 | .... | 528 | 541 | 556 | 573 | 593 |
| | | | | | 14 | .... | 534 | 549 | 567 | 587 | 609 |
| | | | | | 16 | .... | 540 | 557 | 578 | 601 | 626 |
| | | | | | 18 | 529 | 546 | 566 | 589 | 614 | |
| | | | | | 20 | 533 | 552 | 574 | 599 | 628 | |
| | | 7/0 | 1½ | 1.93 | 12 | .... | .... | .... | .... | 721 | 740 |
| | | | | | 14 | .... | .... | .... | 715 | 735 | 757 |
| | | | | | 16 | .... | .... | .... | 725 | 748 | 774 |
| | | | | | 18 | .... | .... | 713 | 736 | 762 | |
| | | | | | 20 | .... | .... | 722 | 747 | 776 | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



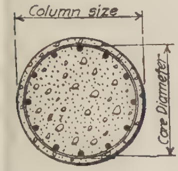
*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 625$

$$P = Af_c[(1+4np') + (n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 31 | 27 | 5/0 | 2⅛ | 1 | 12 | | .... | 579 | 594 | 612 | 631 |
| | | | | | 14 | | 572 | 587 | 605 | 625 | 648 |
| | | | | | 16 | ... | 578 | 596 | 616 | 639 | 664 |
| | | | | | 18 | .... | 584 | 604 | 627 | 653 | 681 |
| | | | | | 20 | 572 | 590 | 612 | 638 | 666 | |
| | | | | | 22 | 576 | 596 | 621 | 648 | 680 | |
| | | 7/0 | 1½ | 1.86 | 12 | .... | .. | .... | .... | 759 | 778 |
| | | | | | 14 | .... | .. | .... | 753 | 773 | 795 |
| | | | | | 16 | | . | ... | 764 | 787 | 812 |
| | | | | | 18 | | .. | 752 | 774 | 800 | 829 |
| | | | | | 20 | | | 760 | 785 | 814 | |
| | | | | | 22 | | | 768 | 796 | 828 | |
| 32 | 28 | 5/0 | 2 | 1 | 12 | | .... | 619 | 634 | 651 | 670 |
| | | | | | 14 | . | 612 | 627 | 645 | 665 | 687 |
| | | | | | 16 | . | 618 | 635 | 656 | 679 | 704 |
| | | | | | 18 | .... | 624 | 644 | 666 | 692 | 721 |
| | | | | | 20 | .... | 630 | 652 | 677 | 706 | 738 |
| | | | | | 22 | 616 | 636 | 660 | 688 | 720 | |
| | | 7/0 | 1½ | 1.80 | 12 | .... | | | .... | 799 | 819 |
| | | | | | 14 | .... | | | 793 | 813 | 835 |
| | | | | | 16 | ... | | | 804 | 827 | 852 |
| | | | | | 18 | ... | .. | .. | 815 | 840 | 869 |
| | | | | | 20 | .. | . | 800 | 825 | 854 | 886 |
| | | | | | 22 | .. | | 808 | 836 | 868 | |
| 33 | 29 | 6/0 | 2¼ | 1 | 12 | .... | .... | 660 | 675 | 693 | 712 |
| | | | | | 14 | ... | .... | 669 | 686 | 706 | 729 |
| | | | | | 16 | .... | 659 | 677 | 697 | 720 | 746 |
| | | | | | 18 | .... | 665 | 685 | 708 | 734 | 763 |
| | | | | | 20 | .... | 671 | 693 | 719 | 747 | 779 |
| | | | | | 22 | 667 | 677 | 702 | 729 | 761 | |
| | | 7/0 | 1½ | 1.73 | 12 | ... | ... | | | 837 | 856 |
| | | | | | 14 | .... | .... | .... | .... | 851 | 873 |
| | | | | | 16 | .. | . | .... | 841 | 864 | 890 |
| | | | | | 18 | .. | .... | .... | 852 | 878 | 907 |
| | | | | | 20 | .. | .... | 838 | 863 | 892 | 924 |
| | | | | | 22 | . | .... | 846 | 874 | 905 | |
| 34 | 30 | 6/0 | 2¼ | 1 | 12 | .... | | 704 | 719 | 736 | 755 |
| | | | | | 14 | .... | . | 712 | 730 | 750 | 772 |
| | | | | | 16 | .... | 703 | 720 | 740 | 763 | 789 |
| | | | | | 18 | .... | 709 | 728 | 751 | 777 | 806 |
| | | | | | 20 | .... | 715 | 737 | 762 | 791 | 823 |
| | | | | | 22 | .... | 721 | 745 | 773 | 804 | 840 |
| | | | | | 24 | 705 | 727 | 753 | 784 | 718 | |
| | | 7/0 | 1½ | 1.67 | 12 | . | .... | .... | ... | 878 | 897 |
| | | | | | 14 | ... | .... | .... | .... | 891 | 914 |
| | | | | | 16 | ... | .... | .... | 882 | 905 | 931 |
| | | | | | 18 | ... | .. | .... | 893 | 919 | 948 |
| | | | | | 20 | .... | .. | 878 | 904 | 932 | 964 |
| | | | | | 22 | .. | .... | 887 | 914 | 946 | 981 |
| | | | | | 24 | .... | .... | 895 | 925 | 960 | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



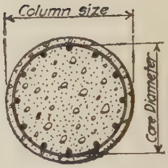
$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right)=15$$

*2500-lb. concrete*
*1:4½ mixture*
$n = 12$
$f_c = 625$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 35 | 31 | 6/0 | 2⅛ | 1 | 14 | .... | .... | 756 | 774 | 794 | 816 |
|  |  |  |  |  | 16 | .... | .... | 764 | 784 | 807 | 833 |
|  |  |  |  |  | 18 | .... | 753 | 772 | 795 | 821 | 850 |
|  |  |  |  |  | 20 | .... | 759 | 781 | 806 | 835 | 867 |
|  |  |  |  |  | 22 | .... | 765 | 789 | 817 | 848 | 884 |
|  |  |  |  |  | 24 | .... | 771 | 797 | 828 | 862 | 901 |
|  |  | 7/0 | 1½ | 1.62 | 14 | .... | .... | .... | .... | 933 | 956 |
|  |  |  |  |  | 16 | .... | .... | .... | 924 | 947 | 972 |
|  |  |  |  |  | 18 | .... | .... | .... | 935 | 961 | 989 |
|  |  |  |  |  | 20 | .... | .... | .... | 946 | 974 | 1006 |
|  |  |  |  |  | 22 | .... | .... | 929 | 956 | 988 | 1023 |
|  |  |  |  |  | 24 | .... | .... | 937 | 967 | 1002 | 1040 |
| 36 | 32 | 6/0 | 2 | 1 | 14 | .... | .... | 802 | 820 | 840 | 862 |
|  |  |  |  |  | 16 | .... | .... | 810 | 830 | 853 | 879 |
|  |  |  |  |  | 18 | .... | .... | 818 | 841 | 867 | 896 |
|  |  |  |  |  | 20 | .... | 805 | 827 | 852 | 881 | 913 |
|  |  |  |  |  | 22 | .... | 811 | 835 | 863 | 894 | 930 |
|  |  |  |  |  | 24 | .... | 817 | 843 | 874 | 908 | 947 |
|  |  | 7/0 | 1½ | 1.57 | 14 | .... | .... | .... | .... | 977 | 999 |
|  |  |  |  |  | 16 | .... | .... | .... | 968 | 991 | 1016 |
|  |  |  |  |  | 18 | .... | .... | .... | 979 | 1004 | 1033 |
|  |  |  |  |  | 20 | .... | .... | .... | 989 | 1018 | 1050 |
|  |  |  |  |  | 22 | .... | .... | 972 | 1000 | 1032 | 1067 |
|  |  |  |  |  | 24 | .... | .... | 981 | 1011 | 1045 | 1084 |
| 37 | 33 | 7/0 | 2¼ | 1 | 14 | .... | .... | .... | 867 | 887 | 909 |
|  |  |  |  |  | 16 | .... | .... | 857 | 878 | 901 | 926 |
|  |  |  |  |  | 18 | .... | .... | 866 | 888 | 914 | 943 |
|  |  |  |  |  | 20 | .... | 852 | 874 | 899 | 928 | 960 |
|  |  |  |  |  | 22 | .... | 858 | 882 | 910 | 942 | 977 |
|  |  |  |  |  | 24 | .... | 864 | 890 | 921 | 955 | 994 |
|  |  |  |  |  | 26 |  | 870 | 899 | 932 | 969 | 1011 |
|  |  | 7/0 | 1½ | 1.52 | 14 |  | .... | .... | .... | 1020 | 1042 |
|  |  |  |  |  | 16 |  | .... | .... | .... | 1033 | 1059 |
|  |  |  |  |  | 18 | .... | .... | .... | 1021 | 1047 | 1076 |
|  |  |  |  |  | 20 | .... | .... | .... | 1032 | 1061 | 1093 |
|  |  |  |  |  | 22 | .... |  | 1015 | 1043 | 1074 | 1110 |
|  |  |  |  |  | 24 | .... | .... | 1023 | 1054 | 1088 | 1127 |
|  |  |  |  |  | 26 |  | .... | 1031 | 1064 | 1102 | 1144 |
| 38 | 34 | 7/0 | 2⅛ | 1 | 14 |  | .... | .... | 916 | 936 | 958 |
|  |  |  |  |  | 16 | .... | .... | 906 | 926 | 949 | 975 |
|  |  |  |  |  | 18 |  | .... | 914 | 937 | 963 | 992 |
|  |  |  |  |  | 20 |  | .... | 923 | 948 | 977 | 1009 |
|  |  |  |  |  | 22 | .... | 907 | 931 | 959 | 990 | 1026 |
|  |  |  |  |  | 24 |  | 913 | 939 | 970 | 1004 | 1043 |
|  |  |  |  |  | 26 |  | 919 | 947 | 980 | 1018 | 1059 |
|  |  | 7/0 | 1½ | 1.48 | 14 |  | .... | .... | .... | 1065 | 1088 |
|  |  |  |  |  | 16 |  | .... | .... | .... | 1079 | 1104 |
|  |  |  |  |  | 18 |  | .... |  | 1067 | 1093 | 1121 |
|  |  |  |  |  | 20 |  | .... | .... | 1078 | 1106 | 1138 |
|  |  |  |  |  | 22 |  |  | .... | 1088 | 1120 | 1155 |
|  |  |  |  |  | 24 |  | .... | 1069 | 1099 | 1134 | 1172 |
|  |  |  |  |  | 26 |  | .... | 1077 | 1110 | 1147 | 1189 |

## ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



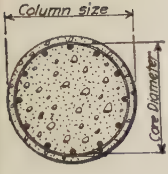
*2500-lb. concrete*
*1:4½ mixture*
$n=12$
$f_c=625$

$$P=Af_c[(1+4np')+(n-1)p]$$

$$Max.\left(\frac{\text{unsupported length}}{\text{diameter}}\right)=15$$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 39 | 35 | 7/0 | 2⅛ | 1 | 14 | .... | .... | .... | 966 | 986 | 1008 |
| | | | | | 16 | .... | .... | 956 | 976 | 999 | 1025 |
| | | | | | 18 | .... | .... | 964 | 987 | 1013 | 1042 |
| | | | | | 20 | .... | .... | 973 | 998 | 1026 | 1059 |
| | | | | | 22 | .... | .... | 981 | 1009 | 1040 | 1076 |
| | | | | | 24 | .... | 963 | 989 | 1020 | 1054 | 1093 |
| | | | | | 26 | .... | 969 | 997 | 1030 | 1068 | 1109 |
| | | 7/0 | 1½ | 1.43 | 14 | .... | .... | .... | .... | 1109 | 1131 |
| | | | | | 16 | .... | .... | .... | .... | 1122 | 1148 |
| | | | | | 18 | .... | .... | .... | 1110 | 1136 | 1165 |
| | | | | | 20 | .... | .... | .... | 1121 | 1150 | 1182 |
| | | | | | 22 | .... | .... | .... | 1132 | 1163 | 1199 |
| | | | | | 24 | .... | .... | 1112 | 1143 | 1177 | 1216 |
| | | | | | 26 | .... | .... | 1120 | 1153 | 1191 | 1233 |
| 40 | 36 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 1028 | 1051 | 1076 |
| | | | | | 18 | .... | .... | .... | 1039 | 1065 | 1093 |
| | | | | | 20 | .... | .... | 1024 | 1050 | 1078 | 1110 |
| | | | | | 22 | .... | .... | 1033 | 1060 | 1092 | 1127 |
| | | | | | 24 | .... | .... | 1041 | 1071 | 1106 | 1144 |
| | | | | | 26 | .... | 1020 | 1049 | 1082 | 1119 | 1161 |
| | | | | | 28 | .... | 1027 | 1057 | 1093 | 1133 | 1178 |
| | | 7/0 | 1½ | 1.40 | 16 | .... | .... | .... | .... | 1173 | 1198 |
| | | | | | 18 | .... | .... | .... | .... | 1187 | 1215 |
| | | | | | 20 | .... | .... | .... | 1172 | 1200 | 1232 |
| | | | | | 22 | .... | .... | .... | 1182 | 1214 | 1249 |
| | | | | | 24 | .... | .... | 1163 | 1193 | 1228 | 1266 |
| | | | | | 26 | .... | .... | 1171 | 1204 | 1241 | 1283 |
| | | | | | 28 | .... | .... | 1179 | 1215 | 1255 | 1300 |
| 41 | 37 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 1081 | 1104 | 1129 |
| | | | | | 18 | .... | .... | 1069 | 1092 | 1118 | 1146 |
| | | | | | 20 | .... | .... | 1077 | 1103 | 1131 | 1163 |
| | | | | | 22 | .... | .... | 1086 | 1113 | 1145 | 1180 |
| | | | | | 24 | .... | 1067 | 1094 | 1124 | 1159 | 1197 |
| | | | | | 26 | .... | 1073 | 1102 | 1135 | 1172 | 1214 |
| | | | | | 28 | .... | 1080 | 1110 | 1146 | 1186 | 1231 |
| | | 7/0 | 1½ | 1.36 | 16 | .... | .... | .... | .... | 1219 | 1244 |
| | | | | | 18 | .... | .... | .... | .... | 1233 | 1261 |
| | | | | | 20 | .... | .... | .... | 1218 | 1246 | 1278 |
| | | | | | 22 | .... | .... | .... | 1228 | 1260 | 1295 |
| | | | | | 24 | .... | .... | .... | 1239 | 1274 | 1312 |
| | | | | | 26 | .... | .... | 1217 | 1250 | 1287 | 1329 |
| | | | | | 28 | .... | .... | 1225 | 1261 | 1301 | 1346 |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



$$P = Af_c[(1+4np')+(n-1)p]$$

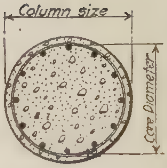
$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

***2500-lb. concrete***
***1:4½ mixture***
***$n = 12$***
***$f_c = 625$***

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 42 | 38 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 1136 | 1159 | 1184 |
| | | | | | 18 | .... | .... | .... | 1147 | 1173 | 1201 |
| | | | | | 20 | .... | .... | 1132 | 1158 | 1186 | 1218 |
| | | | | | 22 | .... | .... | 1141 | 1168 | 1200 | 1235 |
| | | | | | 24 | .... | .... | 1149 | 1179 | 1214 | 1252 |
| | | | | | 26 | .... | 1128 | 1157 | 1190 | 1227 | 1269 |
| | | | | | 28 | .... | 1135 | 1165 | 1201 | 1241 | 1286 |
| | | | | | 30 | .... | 1141 | 1174 | 1212 | 1255 | 1303 |
| | | 7/0 | 1½ | 1.32 | 16 | .... | .... | .... | .... | 1268 | 1294 |
| | | | | | 18 | .... | .... | .... | .... | 1282 | 1311 |
| | | | | | 20 | .... | .... | .... | 1267 | 1296 | 1328 |
| | | | | | 22 | .... | .... | .... | 1278 | 1309 | 1345 |
| | | | | | 24 | .... | .... | .... | 1289 | 1323 | 1362 |
| | | | | | 26 | .... | .... | 1266 | 1299 | 1337 | 1378 |
| | | | | | 28 | .... | .... | 1274 | 1310 | 1350 | 1395 |
| | | | | | 30 | .... | .... | 1283 | 1321 | 1364 | 1412 |
| 43 | 39 | 7/0 | 1⅞ | 1 | 16 | .... | .... | .... | 1191 | 1214 | 1240 |
| | | | | | 18 | .... | .... | .... | 1202 | 1228 | 1257 |
| | | | | | 20 | .... | .... | 1188 | 1213 | 1242 | 1274 |
| | | | | | 22 | .... | .... | 1196 | 1224 | 1255 | 1291 |
| | | | | | 24 | .... | .... | 1204 | 1235 | 1269 | 1308 |
| | | | | | 26 | .... | .... | 1212 | 1245 | 1283 | 1324 |
| | | | | | 28 | .... | 1190 | 1220 | 1256 | 1296 | 1341 |
| | | | | | 30 | .... | 1196 | 1229 | 1267 | 1310 | 1358 |
| | | 7/0 | 1½ | 1.29 | 16 | .... | .... | .... | .... | 1318 | 1344 |
| | | | | | 18 | .... | .... | .... | .... | 1332 | 1361 |
| | | | | | 20 | .... | .... | .... | 1317 | 1345 | 1377 |
| | | | | | 22 | .... | .... | .... | 1327 | 1359 | 1394 |
| | | | | | 24 | .... | .... | .... | 1338 | 1373 | 1411 |
| | | | | | 26 | .... | .... | 1316 | 1349 | 1386 | 1428 |
| | | | | | 28 | .... | .... | 1324 | 1360 | 1400 | 1445 |
| | | | | | 30 | .... | .... | 1333 | 1371 | 1414 | 1461 |
| 44 | 40 | 7/0 | 1⅞ | 1 | 16 | .... | .... | .... | 1248 | 1271 | 1296 |
| | | | | | 18 | .... | .... | .... | 1259 | 1285 | 1313 |
| | | | | | 20 | .... | .... | .... | 1270 | 1298 | 1330 |
| | | | | | 22 | .... | .... | 1253 | 1280 | 1312 | 1347 |
| | | | | | 24 | .... | .... | 1261 | 1291 | 1326 | 1364 |
| | | | | | 26 | .... | .... | 1269 | 1302 | 1339 | 1381 |
| | | | | | 28 | .... | 1247 | 1277 | 1313 | 1353 | 1398 |
| | | | | | 30 | .... | 1253 | 1286 | 1324 | 1367 | 1415 |
| | | 7/0 | 1½ | 1.25 | 16 | .... | .... | .... | .... | 1366 | 1392 |
| | | | | | 18 | .... | .... | .... | .... | 1380 | 1409 |
| | | | | | 20 | .... | .... | .... | 1365 | 1393 | 1425 |
| | | | | | 22 | .... | .... | .... | 1375 | 1407 | 1442 |
| | | | | | 24 | .... | .... | .... | 1386 | 1421 | 1459 |
| | | | | | 26 | .... | .... | .... | 1397 | 1434 | 1476 |
| | | | | | 28 | .... | .... | 1372 | 1408 | 1448 | 1493 |
| | | | | | 30 | .... | .... | 1381 | 1419 | 1462 | 1510 |

**COLUMNS**

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



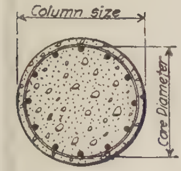
*3000-lb. concrete*
*1:3 mixture*
*$n = 12$*
*$f_c = 750$*

$$P = Af_c[(1+4np')+(n-1)p]$$

$$Max.\left(\frac{unsupported\ length}{diameter}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 12 | 8 | 6 | 1¼ | 1 | 6 | 71 |  |  |  |  |  |
| 13 | 9 | 5 | 1½ | 1 | 6 | 86 |  |  |  |  |  |
|  |  |  |  |  | 8 | 91 |  |  |  |  |  |
| 14 | 10 | 4 | 1½ | 1 | 6 | 102 | 109 |  |  |  |  |
|  |  |  |  |  | 8 | 107 |  |  |  |  |  |
| 15 | 11 | 3 | 1⅝ | 1 | 6 | 121 | 127 | 135 |  |  |  |
|  |  |  |  |  | 8 | 126 | 135 |  |  |  |  |
|  |  |  |  |  | 10 | 131 |  |  |  |  |  |
| 16 | 12 | 2 | 1¾ | 1 | 6 | 141 | 147 | 155 |  |  |  |
|  |  |  |  |  | 8 | 146 | 155 |  |  |  |  |
|  |  |  |  |  | 10 | 151 | 162 |  |  |  |  |
|  |  | 3/0 | 1⅝ | 2 | 6 | .... | 188 | 196 |  |  |  |
|  |  |  |  |  | 8 | 186 | 195 |  |  |  |  |
|  |  |  |  |  | 10 | 191 | 203 |  |  |  |  |
| 17 | 13 | 1 | 1¾ | 1 | 6 | 162 | 169 | 177 | 186 |  |  |
|  |  |  |  |  | 8 | 167 | 176 | 187 |  |  |  |
|  |  |  |  |  | 10 | 172 | 184 |  |  |  |  |
|  |  | 4/0 | 1⅞ | 2 | 6 | .... | 217 | 225 | 234 |  |  |
|  |  |  |  |  | 8 | .... | 224 | 235 |  |  |  |
|  |  |  |  |  | 10 | 220 | 231 |  |  |  |  |
| 18 | 14 | 1 | 1¾ | 1 | 6 | 186 | 193 | 201 | 210 |  |  |
|  |  |  |  |  | 8 | 191 | 200 | 210 |  |  |  |
|  |  |  |  |  | 10 | 196 | 207 | 220 |  |  |  |
|  |  |  |  |  | 12 | 201 | 215 |  |  |  |  |
|  |  | 4/0 | 1¾ | 2 | 6 | .... | .... | 256 | 265 |  |  |
|  |  |  |  |  | 8 | .... | 255 | 266 |  |  |  |
|  |  |  |  |  | 10 | 251 | 263 | 276 |  |  |  |
|  |  |  |  |  | 12 | 257 | 270 |  |  |  |  |
| 19 | 15 | 0 | 1⅞ | 1 | 6 | 211 | 218 | 226 | 235 | 245 |  |
|  |  |  |  |  | 8 | 216 | 225 | 236 | 248 |  |  |
|  |  |  |  |  | 10 | 221 | 233 | 246 |  |  |  |
|  |  |  |  |  | 12 | 226 | 240 |  |  |  |  |
|  |  | 5/0 | 1⅞ | 2 | 6 | .... | .... | 289 | 299 | 309 |  |
|  |  |  |  |  | 8 | .... | 289 | 299 | 312 |  |  |
|  |  |  |  |  | 10 | .... | 296 | 309 |  |  |  |
|  |  |  |  |  | 12 | 290 | 303 |  |  |  |  |
| 20 | 16 | 2/0 | 2⅛ | 1 | 8 | 243 | 252 | 263 | 275 | 289 |  |
|  |  |  |  |  | 10 | 248 | 260 | 273 | 288 |  |  |
|  |  |  |  |  | 12 | 254 | 267 | 283 |  |  |  |
|  |  |  |  |  | 14 | 259 | 274 |  |  |  |  |
|  |  | 6/0 | 2 | 2 | 8 | .... | .... | 335 | 347 | 361 |  |
|  |  |  |  |  | 10 | .... | 332 | 345 | 360 |  |  |
|  |  |  |  |  | 12 | .... | 339 | 355 |  |  |  |
|  |  |  |  |  | 14 | 331 | 347 |  |  |  |  |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



$$P = Af_c[(1+4np')+(n-1)p]$$

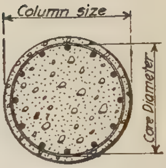
$$\text{Max.}\left(\frac{\textit{unsupported length}}{\textit{diameter}}\right) = 15$$

*3000-lb. concrete*
*1:3 mixture*
$n = 12$
$f_c = 750$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 21 | 17 | 2/0 | 2 | 1 | 8 | 272 | 281 | 292 | 304 | 318 | |
| | | | | | 10 | 277 | 288 | 302 | 317 | | |
| | | | | | 12 | 282 | 296 | 312 | | | |
| | | | | | 14 | 287 | 303 | 321 | | | |
| | | 6/0 | 1⅞ | 2 | 8 | .... | .... | 373 | 385 | 399 | |
| | | | | | 10 | .... | .... | 383 | 398 | | |
| | | | | | 12 | .... | 377 | 393 | | | |
| | | | | | 14 | .... | 385 | 403 | | | |
| 22 | 18 | 3/0 | 2¼ | 1 | 8 | .... | 312 | 322 | 334 | 348 | 363 |
| | | | | | 10 | 308 | 319 | 332 | 347 | 364 | |
| | | | | | 12 | 313 | 326 | 342 | 360 | | |
| | | | | | 14 | 318 | 333 | 352 | | | |
| | | 7/0 | 2 | 2 | 8 | .. | .... | .... | 426 | 440 | 455 |
| | | | | | 10 | . | .... | 424 | 439 | 456 | |
| | | | | | 12 | .... | 418 | 434 | 452 | | |
| | | | | | 14 | ... | 425 | 444 | | | |
| 23 | 19 | 3/0 | 2⅛ | 1 | 8 | .... | 344 | 354 | 366 | 380 | 396 |
| | | | | | 10 | 340 | 351 | 364 | 379 | 397 | |
| | | | | | 12 | 345 | 358 | 374 | 392 | | |
| | | | | | 14 | 350 | 366 | 384 | 405 | | |
| | | | | | 16 | 355 | 373 | 394 | | | |
| | | 7/0 | 1⅞ | 2 | 8 | . | .... | .... | 469 | 482 | 498 |
| | | | | | 10 | ... | .... | 466 | 481 | 499 | |
| | | | | | 12 | .. | .... | 476 | 494 | | |
| | | | | | 14 | | 468 | 486 | 507 | | |
| | | | | | 16 | . | 475 | 496 | | | |
| 24 | 20 | 3/0 | 2 | 1 | 8 | .... | 378 | 388 | 401 | 414 | 430 |
| | | | | | 10 | .... | 385 | 398 | 413 | 431 | 450 |
| | | | | | 12 | 379 | 392 | 408 | 426 | 447 | |
| | | | | | 14 | 384 | 400 | 418 | 439 | | |
| | | | | | 16 | 389 | 407 | 428 | 452 | | |
| | | 7/0 | 1⅞ | 2 | 8 | | .... | .... | 514 | 528 | 543 |
| | | | | | 10 | | .... | ... | 527 | 544 | 563 |
| | | | | | 12 | | .... | 522 | 540 | 560 | |
| | | | | | 14 | ... | .... | 531 | 553 | | |
| | | | | | 16 | . | 520 | 541 | 566 | | |
| 25 | 21 | 4/0 | 2¼ | 1 | 10 | .... | 421 | 434 | 449 | 467 | 486 |
| | | | | | 12 | 415 | 428 | 444 | 462 | 483 | |
| | | | | | 14 | 420 | 436 | 454 | 475 | | |
| | | | | | 16 | 425 | 443 | 464 | 488 | | |
| | | 7/0 | 1¾ | 2 | 10 | .. | .... | .... | 574 | 591 | 610 |
| | | | | | 12 | .. | .... | 570 | 587 | 608 | |
| | | | | | 14 | ... | .... | 579 | 600 | | |
| | | | | | 16 | .... | 568 | 589 | 613 | | |

## COLUMNS

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



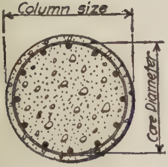
*3000-lb. concrete*
*1:3 mixture*
$n = 12$
$f_c = 750$

$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 26 | 22 | 4/0 | 2⅛ | 1 | 10 | .... | 458 | 472 | 487 | 504 | 523 |
| | | | | | 12 | .... | 466 | 481 | 500 | 520 | 543 |
| | | | | | 14 | 457 | 473 | 491 | 513 | 537 | |
| | | | | | 16 | 462 | 480 | 501 | 526 | | |
| | | | | | 18 | 467 | 488 | 511 | 539 | | |
| | | 7/0 | 1⅝ | 2 | 10 | .... | .... | .... | 623 | 641 | 660 |
| | | | | | 12 | .... | .... | .... | 636 | 657 | 680 |
| | | | | | 14 | .... | .... | 628 | 649 | 674 | |
| | | | | | 16 | .... | .... | 638 | 662 | | |
| | | | | | 18 | .... | 624 | 648 | 675 | | |
| 27 | 23 | 4/0 | 2⅛ | 1 | 10 | .... | 498 | 511 | 526 | 543 | 562 |
| | | | | | 12 | .... | 505 | 521 | 539 | 560 | 583 |
| | | | | | 14 | 497 | 512 | 531 | 552 | 576 | |
| | | | | | 16 | 502 | 520 | 541 | 565 | 592 | |
| | | | | | 18 | 507 | 527 | 551 | 578 | | |
| | | 7/0 | 1⅝ | 2 | 10 | .... | .... | .... | .... | 693 | 712 |
| | | | | | 12 | .... | .... | .... | 688 | 709 | 732 |
| | | | | | 14 | .... | .... | 680 | 701 | 726 | |
| | | | | | 16 | .... | .... | 690 | 714 | 742 | |
| | | | | | 18 | .... | .... | 700 | 727 | | |
| 28 | 24 | 4/0 | 2 | 1 | 10 | .... | .... | 552 | 567 | 584 | 603 |
| | | | | | 12 | .... | 546 | 562 | 580 | 601 | 623 |
| | | | | | 14 | .... | 553 | 572 | 593 | 617 | 644 |
| | | | | | 16 | 543 | 560 | 581 | 606 | 633 | |
| | | | | | 18 | 548 | 568 | 591 | 619 | 650 | |
| | | 7/0 | 1½ | 2 | 10 | .... | .... | .... | .... | 747 | 766 |
| | | | | | 12 | .... | .... | .... | 743 | 763 | 786 |
| | | | | | 14 | .... | .... | .... | 756 | 780 | 806 |
| | | | | | 16 | .... | .... | 744 | 769 | 796 | |
| | | | | | 18 | .... | .... | 754 | 782 | 813 | |
| 29 | 25 | 5/0 | 2¼ | 1 | 10 | .... | .... | 594 | 610 | 627 | 646 |
| | | | | | 12 | .... | 589 | 604 | 623 | 643 | 666 |
| | | | | | 14 | .... | 596 | 614 | 636 | 660 | 687 |
| | | | | | 16 | 585 | 603 | 624 | 648 | 676 | 707 |
| | | | | | 18 | 590 | 610 | 634 | 661 | 692 | |
| | | | | | 20 | 595 | 618 | 644 | 674 | | |
| | | 7/0 | 1½ | 2 | 10 | .... | .... | .... | .... | 804 | 823 |
| | | | | | 12 | .... | .... | .... | .... | 820 | 843 |
| | | | | | 14 | .... | .... | .... | 812 | 836 | 863 |
| | | | | | 16 | .... | .... | .... | 825 | 853 | 884 |
| | | | | | 18 | .... | .... | 811 | 838 | 869 | |
| | | | | | 20 | .... | .... | 821 | 851 | | |
| 30 | 26 | 5/0 | 2¼ | 1 | 12 | .... | 633 | 649 | 667 | 688 | 711 |
| | | | | | 14 | .... | 640 | 659 | 680 | 704 | 731 |
| | | | | | 16 | .... | 648 | 669 | 693 | 720 | 751 |
| | | | | | 18 | 635 | 655 | 678 | 706 | 737 | |
| | | | | | 20 | 640 | 662 | 688 | 719 | 753 | |
| | | 7/0 | 1½ | 1.93 | 12 | .... | .... | .... | .... | 867 | 890 |
| | | | | | 14 | .... | .... | .... | 859 | 883 | 910 |
| | | | | | 16 | .... | .... | .... | 872 | 900 | 930 |
| | | | | | 18 | .... | .... | 858 | 885 | 916 | |
| | | | | | 20 | .... | .... | 868 | 898 | 932 | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



$$P = Af_c[(1+4np')+(n-1)p]$$

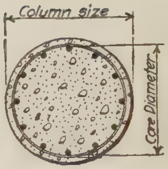
$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right)=15$$

*3000-lb. concrete*
*1:3 mixture*
$n=12$
$f_c=750$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 31 | 27 | 5/0 | 2⅛ | 1 | 12 | .... | .... | 695 | 713 | 734 | 757 |
|  |  |  |  |  | 14 | .... | 687 | 705 | 726 | 750 | 777 |
|  |  |  |  |  | 16 | .... | 694 | 715 | 739 | 767 | 797 |
|  |  |  |  |  | 18 | .... | 701 | 725 | 752 | 783 | 818 |
|  |  |  |  |  | 20 | 686 | 708 | 735 | 765 | 800 |  |
|  |  |  |  |  | 22 | 691 | 716 | 745 | 778 | 816 |  |
|  |  | 7/0 | 1½ | 1.86 | 12 | .... | .... | .... | .... | 910 | 933 |
|  |  |  |  |  | 14 | .... | .... | .... | 902 | 926 | 953 |
|  |  |  |  |  | 16 | .... | .... | .... | 915 | 943 | 974 |
|  |  |  |  |  | 18 | .... | .... | 901 | 928 | 959 | 994 |
|  |  |  |  |  | 20 | .... | .... | 911 | 941 | 976 |  |
|  |  |  |  |  | 22 | .... | .... | 921 | 954 | 992 |  |
| 32 | 28 | 5/0 | 2 | 1 | 12 | .... | .... | 743 | 761 | 782 | 805 |
|  |  |  |  |  | 14 | .... | 735 | 753 | 774 | 798 | 825 |
|  |  |  |  |  | 16 | .... | 742 | 763 | 787 | 815 | 845 |
|  |  |  |  |  | 18 | .... | 749 | 773 | 800 | 831 | 866 |
|  |  |  |  |  | 20 | .... | 756 | 783 | 813 | 848 | 886 |
|  |  |  |  |  | 22 | 739 | 764 | 793 | 826 | 864 |  |
|  |  | 7/0 | 1½ | 1.80 | 12 | .... | .... | .... | .... | 957 | 981 |
|  |  |  |  |  | 14 | .... | .... | .... | 950 | 974 | 1001 |
|  |  |  |  |  | 16 | .... | .... | .... | 963 | 990 | 1021 |
|  |  |  |  |  | 18 | .... | .... | .... | 976 | 1007 | 1041 |
|  |  |  |  |  | 20 | .... | .... | 958 | 989 | 1023 | 1061 |
|  |  |  |  |  | 22 | .... | .... | 968 | 1002 | 1039 |  |
| 33 | 29 | 6/0 | 2¼ | 1 | 12 | .... | .... | 793 | 811 | 832 | 855 |
|  |  |  |  |  | 14 | .... | .... | 803 | 824 | 848 | 875 |
|  |  |  |  |  | 16 | .... | 791 | 812 | 837 | 864 | 895 |
|  |  |  |  |  | 18 | .... | 799 | 822 | 850 | 881 | 915 |
|  |  |  |  |  | 20 | .... | 806 | 832 | 863 | 897 | 936 |
|  |  |  |  |  | 22 | 789 | 813 | 842 | 876 | 913 |  |
|  |  | 7/0 | 1½ | 1.73 | 12 | .... | .... | .... | .... | 1004 | 1027 |
|  |  |  |  |  | 14 | .... | .... | .... | .... | 1020 | 1047 |
|  |  |  |  |  | 16 | .... | .... | .... | 1009 | 1037 | 1067 |
|  |  |  |  |  | 18 | .... | .... | .... | 1022 | 1053 | 1088 |
|  |  |  |  |  | 20 | .... | .... | 1005 | 1035 | 1070 | 1108 |
|  |  |  |  |  | 22 | .... | .... | 1015 | 1048 | 1086 |  |
| 34 | 30 | 6/0 | 2¼ | 1 | 12 | .... | .... | 844 | 862 | 883 | 906 |
|  |  |  |  |  | 14 | .... | .... | 854 | 875 | 899 | 926 |
|  |  |  |  |  | 16 | .... | 843 | 864 | 888 | 916 | 946 |
|  |  |  |  |  | 18 | .... | 850 | 874 | 901 | 932 | 967 |
|  |  |  |  |  | 20 | .... | 857 | 884 | 914 | 949 | 987 |
|  |  |  |  |  | 22 | .... | 865 | 894 | 927 | 965 | 1007 |
|  |  |  |  |  | 24 | 845 | 872 | 904 | 940 | 981 |  |
|  |  | 7/0 | 1½ | 1.67 | 12 | .... | .... | .... | .... | 1053 | 1076 |
|  |  |  |  |  | 14 | .... | .... | .... | .... | 1069 | 1096 |
|  |  |  |  |  | 16 | .... | .... | .... | 1058 | 1086 | 1116 |
|  |  |  |  |  | 18 | .... | .... | .... | 1071 | 1101 | 1137 |
|  |  |  |  |  | 20 | .... | .... | 1054 | 1084 | 1118 | 1157 |
|  |  |  |  |  | 22 | .... | .... | 1063 | 1097 | 1135 | 1177 |
|  |  |  |  |  | 24 | .... | .... | 1073 | 1110 | 1151 |  |

## COLUMNS

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



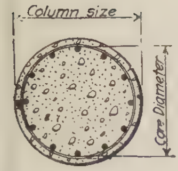
*3000-lb. concrete*
*1:3 mixture*
$n = 12$
$f_c = 750$

$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 35 | 31 | 6/0 | 2 1/8 | 1 | 14 | .... | .... | 907 | 929 | 953 | 980 |
|  |  |  |  |  | 16 | .... | .... | 917 | 941 | 969 | 1000 |
|  |  |  |  |  | 18 | .... | 903 | 927 | 954 | 985 | 1020 |
|  |  |  |  |  | 20 | .... | 911 | 937 | 967 | 1002 | 1040 |
|  |  |  |  |  | 22 | .... | 918 | 947 | 980 | 1018 | 1061 |
|  |  |  |  |  | 24 | .... | 925 | 957 | 993 | 1035 | 1081 |
|  |  | 7/0 | 1 1/2 | 1.62 | 14 | .... | .... | .... | .... | 1123 | 1150 |
|  |  |  |  |  | 16 | .... | .... | .... | 1111 | 1139 | 1170 |
|  |  |  |  |  | 18 | .... | .... | .... | 1124 | 1155 | 1190 |
|  |  |  |  |  | 20 | .... | .... | .... | 1137 | 1172 | 1210 |
|  |  |  |  |  | 22 | .... | .... | 1117 | 1150 | 1188 | 1231 |
|  |  |  |  |  | 24 | .... | .... | 1127 | 1163 | 1205 | 1251 |
| 36 | 32 | 6/0 | 2 | 1 | 14 | .... | .... | 962 | 983 | 1007 | 1034 |
|  |  |  |  |  | 16 | .... | .... | 972 | 996 | 1024 | 1055 |
|  |  |  |  |  | 18 | .... | .... | 982 | 1009 | 1040 | 1075 |
|  |  |  |  |  | 20 | .... | 965 | 992 | 1022 | 1056 | 1095 |
|  |  |  |  |  | 22 | .... | 973 | 1002 | 1035 | 1073 | 1115 |
|  |  |  |  |  | 24 | .... | 980 | 1012 | 1048 | 1089 | 1136 |
|  |  | 7/0 | 1 1/2 | 1.57 | 14 | .... | .... | .... | .... | 1173 | 1200 |
|  |  |  |  |  | 16 | .... | .... | .... | 1162 | 1189 | 1220 |
|  |  |  |  |  | 18 | .... | .... | .... | 1175 | 1206 | 1240 |
|  |  |  |  |  | 20 | .... | .... | .... | 1187 | 1222 | 1260 |
|  |  |  |  |  | 22 | .... | .... | 1167 | 1200 | 1239 | 1280 |
|  |  |  |  |  | 24 | .... | .... | 1177 | 1213 | 1256 | 1301 |
| 37 | 33 | 7/0 | 2 1/4 | 1 | 14 | .... | .... | .... | 1040 | 1064 | 1091 |
|  |  |  |  |  | 16 | .... | .... | 1028 | 1053 | 1080 | 1111 |
|  |  |  |  |  | 18 | .... | .... | 1038 | 1066 | 1097 | 1131 |
|  |  |  |  |  | 20 | .... | 1022 | 1048 | 1079 | 1113 | 1151 |
|  |  |  |  |  | 22 | .... | 1029 | 1058 | 1092 | 1130 | 1172 |
|  |  |  |  |  | 24 | .... | 1037 | 1068 | 1105 | 1146 | 1192 |
|  |  |  |  |  | 26 | .... | 1044 | 1078 | 1118 | 1164 | 1212 |
|  |  | 7/0 | 1 1/2 | 1.52 | 14 | .... | .... | .... | .... | 1225 | 1251 |
|  |  |  |  |  | 16 | .... | .... | .... | .... | 1241 | 1272 |
|  |  |  |  |  | 18 | .... | .... | .... | 1226 | 1257 | 1292 |
|  |  |  |  |  | 20 | .... | .... | .... | 1239 | 1274 | 1312 |
|  |  |  |  |  | 22 | .... | .... | 1219 | 1252 | 1290 | 1332 |
|  |  |  |  |  | 24 | .... | .... | 1229 | 1265 | 1307 | 1353 |
|  |  |  |  |  | 26 | .... | .... | 1239 | 1278 | 1323 | 1373 |
| 38 | 34 | 7/0 | 2 1/8 | 1 | 14 | .... | .... | .... | 1098 | 1123 | 1149 |
|  |  |  |  |  | 16 | .... | .... | 1087 | 1111 | 1139 | 1170 |
|  |  |  |  |  | 18 | .... | .... | 1097 | 1124 | 1155 | 1190 |
|  |  |  |  |  | 20 | .... | .... | 1107 | 1137 | 1172 | 1210 |
|  |  |  |  |  | 22 | .... | 1088 | 1117 | 1150 | 1188 | 1230 |
|  |  |  |  |  | 24 | .... | 1095 | 1127 | 1163 | 1205 | 1251 |
|  |  |  |  |  | 26 | .... | 1102 | 1137 | 1176 | 1221 | 1271 |
|  |  | 7/0 | 1 1/2 | 1.48 | 14 | .... | .... | .... | .... | 1279 | 1306 |
|  |  |  |  |  | 16 | .... | .... | .... | .... | 1296 | 1326 |
|  |  |  |  |  | 18 | .... | .... | .... | 1281 | 1312 | 1347 |
|  |  |  |  |  | 20 | .... | .... | .... | 1294 | 1328 | 1367 |
|  |  |  |  |  | 22 | .... | .... | .... | 1307 | 1345 | 1387 |
|  |  |  |  |  | 24 | .... | .... | 1283 | 1320 | 1361 | 1407 |
|  |  |  |  |  | 26 | .... | .... | 1293 | 1333 | 1378 | 1428 |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS



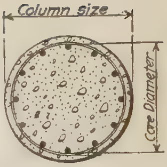
$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

*3000-lb. concrete*
*1:3 mixture*
$n = 12$
$f_c = 750$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 39 | 35 | 7/0 | 2⅛ | 1 | 14 | | .... | .... | 1158 | 1183 | 1210 |
| | | | | | 16 | | .... | 1147 | 1172 | 1199 | 1230 |
| | | | | | 18 | .... | .... | 1157 | 1185 | 1216 | 1250 |
| | | | | | 20 | .... | .... | 1167 | 1197 | 1232 | 1270 |
| | | | | | 22 | .... | 1148 | 1177 | 1210 | 1248 | 1291 |
| | | | | | 24 | .... | 1155 | 1187 | 1223 | 1265 | 1311 |
| | | | | | 26 | .... | 1163 | 1197 | 1236 | 1281 | 1331 |
| | | 7/0 | 1½ | 1.43 | 14 | | .... | .... | .... | 1334 | 1361 |
| | | | | | 16 | .... | .... | .... | .... | 1351 | 1381 |
| | | | | | 18 | .... | .... | .... | 1336 | 1367 | 1402 |
| | | | | | 20 | .... | .... | .... | 1349 | 1383 | 1422 |
| | | | | | 22 | .... | .... | .... | 1362 | 1400 | 1442 |
| | | | | | 24 | .... | .... | 1339 | 1375 | 1416 | 1462 |
| | | | | | 26 | .... | .... | 1348 | 1388 | 1433 | 1483 |
| 40 | 36 | 7/0 | 2 | 1 | 16 | | .... | .... | 1233 | 1261 | 1292 |
| | | | | | 18 | .... | .... | .... | 1246 | 1277 | 1312 |
| | | | | | 20 | .... | .... | 1229 | 1259 | 1294 | 1332 |
| | | | | | 22 | .... | .... | 1239 | 1272 | 1310 | 1353 |
| | | | | | 24 | .... | .... | 1249 | 1285 | 1327 | 1373 |
| | | | | | 26 | .... | 1225 | 1259 | 1298 | 1343 | 1393 |
| | | | | | 28 | .... | 1231 | 1269 | 1311 | 1359 | 1413 |
| | | 7/0 | 1½ | 1.40 | 16 | .... | .... | .... | .... | 1406 | 1437 |
| | | | | | 18 | .... | .... | .... | .... | 1423 | 1457 |
| | | | | | 20 | .... | .... | .... | 1404 | 1439 | 1477 |
| | | | | | 22 | .... | .... | .... | 1417 | 1455 | 1498 |
| | | | | | 24 | .... | .... | 1394 | 1430 | 1472 | 1518 |
| | | | | | 26 | .... | .... | 1404 | 1443 | 1488 | 1538 |
| | | | | | 28 | .... | .... | 1414 | 1456 | 1505 | 1558 |
| 41 | 37 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 1297 | 1325 | 1355 |
| | | | | | 18 | .... | .... | 1283 | 1310 | 1341 | 1376 |
| | | | | | 20 | .... | .... | 1293 | 1323 | 1357 | 1396 |
| | | | | | 22 | .... | .... | 1303 | 1336 | 1374 | 1416 |
| | | | | | 24 | .... | 1281 | 1312 | 1349 | 1390 | 1436 |
| | | | | | 26 | .... | 1288 | 1322 | 1361 | 1407 | 1457 |
| | | | | | 28 | | 1295 | 1332 | 1375 | 1423 | 1477 |
| | | 7/0 | 1½ | 1.36 | 16 | | .... | | .... | 1462 | 1492 |
| | | | | | 18 | .... | | | .... | 1478 | 1513 |
| | | | | | 20 | .... | .... | .... | 1460 | 1495 | 1533 |
| | | | | | 22 | | .... | .... | 1473 | 1511 | 1553 |
| | | | | | 24 | .... | | .... | 1486 | 1527 | 1573 |
| | | | | | 26 | | .... | 1459 | 1499 | 1544 | 1594 |
| | | | | | 28 | .... | | 1469 | 1512 | 1560 | 1614 |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS

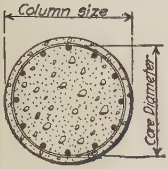


***3000-lb. concrete***
***1:3 mixture***
$n = 12$
$f_c = 750$

$$P = Af_c[(1+4np')+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{unsupported length}}{\text{diameter}}\right) = 15$$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 42 | 38 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 1362 | 1390 | 1421 |
| | | | | | 18 | .... | .... | .... | 1375 | 1406 | 1441 |
| | | | | | 20 | .... | .... | 1358 | 1388 | 1423 | 1461 |
| | | | | | 22 | .... | .... | 1368 | 1401 | 1439 | 1482 |
| | | | | | 24 | .... | .... | 1378 | 1414 | 1456 | 1502 |
| | | | | | 26 | .... | 1354 | 1388 | 1427 | 1472 | 1522 |
| | | | | | 28 | .... | 1360 | 1398 | 1440 | 1488 | 1542 |
| | | | | | 30 | .... | 1368 | 1408 | 1453 | 1504 | 1563 |
| | | 7/0 | 1½ | 1.32 | 16 | .... | .... | .... | .... | 1520 | 1551 |
| | | | | | 18 | .... | .... | .... | .... | 1537 | 1571 |
| | | | | | 20 | .... | .... | .... | 1519 | 1553 | 1591 |
| | | | | | 22 | .... | .... | .... | 1532 | 1570 | 1612 |
| | | | | | 24 | .... | .... | .... | 1545 | 1586 | 1632 |
| | | | | | 26 | .... | .... | 1518 | 1558 | 1603 | 1652 |
| | | | | | 28 | .... | .... | 1528 | 1571 | 1619 | 1673 |
| | | | | | 30 | .... | .... | 1538 | 1583 | 1635 | 1693 |
| 43 | 39 | 7/0 | 1⅞ | 1 | 16 | .... | .... | .... | 1430 | 1457 | 1488 |
| | | | | | 18 | .... | .... | .... | 1443 | 1474 | 1508 |
| | | | | | 20 | .... | .... | 1425 | 1456 | 1490 | 1528 |
| | | | | | 22 | .... | .... | 1435 | 1469 | 1506 | 1549 |
| | | | | | 24 | .... | .... | 1445 | 1482 | 1523 | 1569 |
| | | | | | 26 | .... | .... | 1455 | 1494 | 1539 | 1589 |
| | | | | | 28 | .... | 1428 | 1465 | 1507 | 1556 | 1609 |
| | | | | | 30 | .... | 1435 | 1475 | 1520 | 1572 | 1630 |
| | | 7/0 | 1½ | 1.29 | 16 | .... | .... | .... | .... | 1583 | 1613 |
| | | | | | 18 | .... | .... | .... | .... | 1599 | 1634 |
| | | | | | 20 | .... | .... | .... | 1581 | 1615 | 1654 |
| | | | | | 22 | .... | .... | .... | 1594 | 1632 | 1674 |
| | | | | | 24 | .... | .... | .... | 1607 | 1648 | 1694 |
| | | | | | 26 | .... | .... | 1580 | 1620 | 1665 | 1715 |
| | | | | | 28 | .... | .... | 1590 | 1633 | 1681 | 1735 |
| | | | | | 30 | .... | .... | 1600 | 1645 | 1697 | 1755 |
| 44 | 40 | 7/0 | 1⅞ | 1 | 16 | .... | .... | .... | 1498 | 1526 | 1557 |
| | | | | | 18 | .... | .... | .... | 1511 | 1542 | 1577 |
| | | | | | 20 | .... | .... | .... | 1524 | 1559 | 1597 |
| | | | | | 22 | .... | .... | 1504 | 1537 | 1575 | 1618 |
| | | | | | 24 | .... | .... | 1514 | 1550 | 1592 | 1638 |
| | | | | | 26 | .... | .... | 1524 | 1563 | 1608 | 1658 |
| | | | | | 28 | .... | 1496 | 1534 | 1576 | 1624 | 1678 |
| | | | | | 30 | .... | 1504 | 1544 | 1589 | 1641 | 1699 |
| | | 7/0 | 1½ | 1.25 | 16 | .... | .... | .... | .... | 1639 | 1670 |
| | | | | | 18 | .... | .... | .... | .... | 1656 | 1690 |
| | | | | | 20 | .... | .... | .... | 1637 | 1672 | 1710 |
| | | | | | 22 | .... | .... | .... | 1650 | 1688 | 1731 |
| | | | | | 24 | .... | .... | .... | 1663 | 1705 | 1751 |
| | | | | | 26 | .... | .... | .... | 1676 | 1721 | 1771 |
| | | | | | 28 | .... | .... | 1647 | 1689 | 1738 | 1791 |
| | | | | | 30 | .... | .... | 1657 | 1702 | 1754 | 1812 |



# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

$$P = Af_c[1+(n-1)p]+2f_s p'A$$
$$f_s = 20{,}000$$
$$\text{Max.}\left(\frac{length}{diameter}\right) = 15$$

*1:6 mixture*
$n = 15$
$f_c = 500$

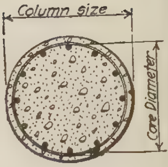
| Size of column (inches) | Diameter of core (inches) | Spirals: Size No. (A. S. & W. Co.) | Spirals: Pitch (inches) | Spirals: Per cent of core | Number of rods | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 8 | 6 | 1¼ | 1 | 6 | 58 | | | | | |
| 13 | 9 | 5 | 1½ | 1 | 6 | 70 | | | | | |
| | | | | | 8 | 74 | | | | | |
| 14 | 10 | 4 | 1½ | 1 | 6 | 83 | 89 | | | | |
| | | | | | 8 | 88 | | | | | |
| 15 | 11 | 3 | 1⅝ | 1 | 6 | 98 | 104 | 111 | | | |
| | | | | | 8 | 103 | 110 | | | | |
| | | | | | 10 | 107 | | | | | |
| 16 | 12 | 2 | 1¾ | 1 | 6 | 115 | 120 | 127 | | | |
| | | | | | 8 | 119 | 126 | | | | |
| | | | | | 10 | 123 | 133 | | | | |
| | | 3/0 | 1⅝ | 2 | 6 | .... | 166 | 172 | | | |
| | | | | | 8 | 164 | 172 | | | | |
| | | | | | 10 | 168 | 178 | | | | |
| 17 | 13 | 1 | 1¾ | 1 | 6 | 132 | 138 | 145 | 152 | | |
| | | | | | 8 | 137 | 144 | 153 | | | |
| | | | | | 10 | 141 | 150 | | | | |
| | | 4/0 | 1⅞ | 2 | 6 | .... | 191 | 198 | 205 | | |
| | | | | | 8 | .... | 197 | 206 | | | |
| | | | | | 10 | 194 | 203 | | | | |
| 18 | 14 | 1 | 1¾ | 1 | 6 | 151 | 157 | 164 | 171 | | |
| | | | | | 8 | 156 | 163 | 172 | | | |
| | | | | | 10 | 160 | 169 | 181 | | | |
| | | | | | 12 | 164 | 176 | | | | |
| | | 4/0 | 1¾ | 2 | 6 | .... | .... | 225 | 233 | | |
| | | | | | 8 | .... | 225 | 234 | | | |
| | | | | | 10 | 222 | 231 | 242 | | | |
| | | | | | 12 | 226 | 237 | | | | |
| 19 | 15 | 0 | 1⅞ | 1 | 6 | 172 | 178 | 184 | 192 | 201 | |
| | | | | | 8 | 176 | 184 | 193 | 203 | | |
| | | | | | 10 | 180 | 190 | 201 | | | |
| | | | | | 12 | 185 | 196 | | | | |
| | | 5/0 | 1⅞ | 2 | 6 | .... | .... | 255 | 263 | 271 | |
| | | | | | 8 | .... | 254 | 263 | 274 | | |
| | | | | | 10 | .... | 261 | 272 | | | |
| | | | | | 12 | 255 | 267 | | | | |
| 20 | 16 | 2/0 | 2⅛ | 1 | 8 | 198 | 206 | 215 | 225 | 237 | |
| | | | | | 10 | 202 | 212 | 223 | 236 | | |
| | | | | | 12 | 207 | 218 | 231 | | | |
| | | | | | 14 | 211 | 224 | | | | |
| | | 6/0 | 2 | 2 | 8 | .... | .... | 295 | 305 | 317 | |
| | | | | | 10 | .... | 292 | 303 | 316 | | |
| | | | | | 12 | .... | 299 | 312 | | | |
| | | | | | 14 | 291 | 305 | | | | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

$$P = Af_c[1 + (n - 1)p] + 2f_s p'A$$

$$f_s = 20{,}000$$

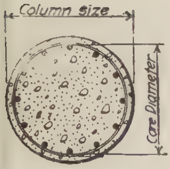
$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 15$$



***1:6 mixture***
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | 5/8 | 3/4 | 7/8 | 1 | 1⅛ | 1¼ |
| 21 | 17 | 2/0 | 2 | 1 | 8 | 221 | 229 | 238 | 248 | 260 |  |
|  |  |  |  |  | 10 | 226 | 235 | 246 | 259 |  |  |
|  |  |  |  |  | 12 | 230 | 241 | 255 |  |  |  |
|  |  |  |  |  | 14 | 234 | 248 | 263 |  |  |  |
|  |  | 6/0 | 1⅞ | 2 | 8 | .... | .... | 329 | 339 | 351 |  |
|  |  |  |  |  | 10 | .... | ... | 337 | 350 |  |  |
|  |  |  |  |  | 12 | .... | 332 | 346 |  |  |  |
|  |  |  |  |  | 14 | .... | 338 | 354 |  |  |  |
| 22 | 18 | 3/0 | 2¼ | 1 | 8 | .... | 254 | 263 | 273 | 285 | 298 |
|  |  |  |  |  | 10 | 250 | 260 | 271 | 284 | 299 |  |
|  |  |  |  |  | 12 | 255 | 266 | 280 | 295 |  |  |
|  |  |  |  |  | 14 | 259 | 272 | 288 |  |  |  |
|  |  | 7/0 | 2 | 2 | 8 | .... | .... | .... | 375 | 386 | 400 |
|  |  |  |  |  | 10 | .... | ... | 373 | 386 | 400 |  |
|  |  |  |  |  | 12 | ... | 368 | 381 | 397 |  |  |
|  |  |  |  |  | 14 | .... | 374 | 390 |  |  |  |
| 23 | 19 | 3/0 | 2⅛ | 1 | 8 | .... | 280 | 289 | 299 | 311 | 324 |
|  |  |  |  |  | 10 | 277 | 286 | 297 | 310 | 325 |  |
|  |  |  |  |  | 12 | 281 | 292 | 306 | 321 |  |  |
|  |  |  |  |  | 14 | 285 | 298 | 314 | 332 |  |  |
|  |  |  |  |  | 16 | 289 | 305 | 322 |  |  |  |
|  |  | 7/0 | 1⅞ | 2 | 8 | .... | ... | .... | 412 | 424 | 437 |
|  |  |  |  |  | 10 | .... | .... | 411 | 423 | 438 |  |
|  |  |  |  |  | 12 | ... | ... | 419 | 434 |  |  |
|  |  |  |  |  | 14 | ... | 412 | 427 | 445 |  |  |
|  |  |  |  |  | 16 | .. | 418 | 436 |  |  |  |
| 24 | 20 | 3/0 | 2 | 1 | 8 | .. | 307 | 316 | 327 | 338 | 351 |
|  |  |  |  |  | 10 | ... | 314 | 325 | 338 | 352 | 369 |
|  |  |  |  |  | 12 | 308 | 320 | 333 | 349 | 366 |  |
|  |  |  |  |  | 14 | 313 | 326 | 342 | 360 |  |  |
|  |  |  |  |  | 16 | 317 | 332 | 350 | 371 |  |  |
|  |  | 7/0 | 1⅞ | 2 | 8 | .... | .... | ... | 452 | 464 | 477 |
|  |  |  |  |  | 10 | .... | .... | .... | 463 | 478 | 494 |
|  |  |  |  |  | 12 | ... | .... | 459 | 474 | 492 |  |
|  |  |  |  |  | 14 | .... | .... | 467 | 485 |  |  |
|  |  |  |  |  | 16 | .... | 458 | 476 | 496 |  |  |
| 25 | 21 | 4/0 | 2¼ | 1 | 10 | ... | 343 | 354 | 367 | 381 | 398 |
|  |  |  |  |  | 12 | 337 | 349 | 362 | 378 | 395 |  |
|  |  |  |  |  | 14 | 342 | 355 | 371 | 389 |  |  |
|  |  |  |  |  | 16 | 346 | 361 | 379 | 400 |  |  |
|  |  | 7/0 | 1¾ | 2 | 10 | .... | .... | .... | 505 | 520 | 536 |
|  |  |  |  |  | 12 | .. | .... | 501 | 516 | 534 |  |
|  |  |  |  |  | 14 | .... | .... | 509 | 527 |  |  |
|  |  |  |  |  | 16 | .... | 500 | 518 | 538 |  |  |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS



$$P = Af_c[1+(n-1)p]+2f_s p'A$$

$$f_s = 20,000$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 15$$

**1:6 mixture**
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 26 | 22 | 4/0 | 2 1/8 | 1 | 10 | ... | 373 | 384 | 397 | 412 | 428 |
|  |  |  |  |  | 12 | .... | 379 | 393 | 408 | 425 | 445 |
|  |  |  |  |  | 14 | 372 | 385 | 401 | 419 | 439 |  |
|  |  |  |  |  | 16 | 376 | 391 | 409 | 430 |  |  |
|  |  |  |  |  | 18 | 381 | 398 | 418 | 441 |  |  |
|  |  | 7/0 | 1 5/8 | 2 | 10 | .... | ... | .... | 549 | 564 | 580 |
|  |  |  |  |  | 12 | .... | .... | .... | 560 | 578 | 597 |
|  |  |  |  |  | 14 | .... | ... | 553 | 571 | 592 |  |
|  |  |  |  |  | 16 | .... | .... | 561 | 582 |  |  |
|  |  |  |  |  | 18 | .... | 550 | 570 | 593 |  |  |
| 27 | 23 | 4/0 | 2 1/8 | 1 | 10 | .... | 405 | 416 | 429 | 443 | 460 |
|  |  |  |  |  | 12 | .... | 411 | 424 | 440 | 457 | 477 |
|  |  |  |  |  | 14 | 404 | 417 | 433 | 451 | 171 |  |
|  |  |  |  |  | 16 | 408 | 423 | 441 | 462 | 485 |  |
|  |  |  |  |  | 18 | 413 | 430 | 450 | 473 |  |  |
|  |  | 7/0 | 1 5/8 | 2 | 10 | .... | .... | ... | .... | 610 | 626 |
|  |  |  |  |  | 12 | .... | ... | .... | 606 | 624 | 643 |
|  |  |  |  |  | 14 | .... | .... | 599 | 617 | 638 |  |
|  |  |  |  |  | 16 | .... | .... | 607 | 628 | 651 |  |
|  |  |  |  |  | 18 | .... | .... | 616 | 639 |  |  |
| 28 | 24 | 4/0 | 2 | 1 | 10 | .... | .... | 449 | 462 | 477 | 493 |
|  |  |  |  |  | 12 | .... | 444 | 458 | 473 | 491 | 510 |
|  |  |  |  |  | 14 | .... | 450 | 466 | 484 | 505 | 527 |
|  |  |  |  |  | 16 | 441 | 457 | 474 | 495 | 518 |  |
|  |  |  |  |  | 18 | 446 | 463 | 483 | 506 | 532 |  |
|  |  | 7/0 | 1 1/2 | 2 | 10 | .... | .... | .... | .... | 658 | 674 |
|  |  |  |  |  | 12 | .... | .... | .... | 654 | 672 | 691 |
|  |  |  |  |  | 14 | .... | .. | .... | 665 | 686 | 708 |
|  |  |  |  |  | 16 | .... | .... | 655 | 676 | 699 |  |
|  |  |  |  |  | 18 | .... | .... | 664 | 687 | 713 |  |
| 29 | 25 | 5/0 | 2 1/4 | 1 | 10 | .... | .... | 484 | 497 | 511 | 528 |
|  |  |  |  |  | 12 | .... | 479 | 492 | 508 | 525 | 545 |
|  |  |  |  |  | 14 | .... | 485 | 501 | 519 | 539 | 562 |
|  |  |  |  |  | 16 | 476 | 491 | 509 | 530 | 553 | 579 |
|  |  |  |  |  | 18 | 480 | 497 | 518 | 541 | 567 |  |
|  |  |  |  |  | 20 | 485 | 504 | 526 | 551 |  |  |
|  |  | 7/0 | 1 1/2 | 2 | 10 | .... | .... | .... | .... | 708 | 724 |
|  |  |  |  |  | 12 | .... | .... | .... | .... | 722 | 741 |
|  |  |  |  |  | 14 | .... | .... | .... | 715 | 736 | 758 |
|  |  |  |  |  | 16 | .... | .... | .... | 726 | 749 | 776 |
|  |  |  |  |  | 18 | .... | .... | 714 | 737 | 763 |  |
|  |  |  |  |  | 20 | .... | .... | 722 | 748 |  |  |
| 30 | 26 | 5/0 | 2 1/4 | 1 | 12 | .... | 515 | 528 | 544 | 561 | 581 |
|  |  |  |  |  | 14 | .... | 521 | 537 | 555 | 575 | 598 |
|  |  |  |  |  | 16 | .... | 527 | 545 | 566 | 589 | 615 |
|  |  |  |  |  | 18 | 516 | 533 | 554 | 577 | 603 |  |
|  |  |  |  |  | 20 | 521 | 540 | 562 | 588 |  |  |
|  |  | 7/0 | 1 1/2 | 1.93 | 12 | .... | .... | .... | .... | 759 | 778 |
|  |  |  |  |  | 14 | .... | .... | .... | 752 | 773 | 796 |
|  |  |  |  |  | 16 | .... | .... | .... | 763 | 787 | 813 |
|  |  |  |  |  | 18 | .... | .... | 751 | 774 | 801 |  |
|  |  |  |  |  | 20 | .... | .... | 760 | 785 | 815 |  |

TABLE 38

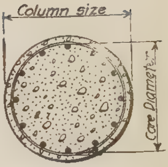
# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

$$P = Af_c[1+(n-1)p]+2f_s p'A$$

$$f_s = 20{,}000$$

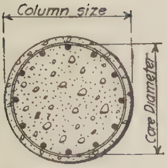
$$\text{Max.}\left(\frac{length}{diameter}\right) = 15$$

*1:6 mixture*
$n = 15$
$f_c = 500$



| Size of column (inches) | Diameter of core (inches) | Spirals: Size No. (A. S. & W. Co.) | Spirals: Pitch (inches) | Spirals: Per cent of core | Number of rods | Size of vertical round rods: ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 27 | 5/0 | 2⅛ | 1 | 12 | .... | .... | 566 | 581 | 599 | 618 |
| | | | | | 14 | | 559 | 574 | 592 | 613 | 636 |
| | | | | | 16 | .... | 565 | 583 | 603 | 627 | 653 |
| | | | | | 18 | .... | 571 | 591 | 614 | 641 | 670 |
| | | | | | 20 | 558 | 577 | 599 | 625 | 654 | |
| | | | | | 22 | 563 | 583 | 608 | 636 | 668 | |
| | | 7/0 | 1½ | 1.86 | 12 | .... | .... | .... | .... | 796 | 816 |
| | | | | | 14 | .... | .... | .... | 790 | 810 | 833 |
| | | | | | 16 | .... | | .... | 801 | 824 | 850 |
| | | | | | 18 | .... | | 789 | 812 | 838 | 868 |
| | | | | | 20 | .... | .... | 797 | 823 | 852 | |
| | | | | | 22 | .... | .... | 806 | 834 | 866 | |
| 32 | 28 | 5/0 | 2 | 1 | 12 | .... | .... | 605 | 620 | 638 | 657 |
| | | | | | 14 | .... | 597 | 613 | 631 | 652 | 674 |
| | | | | | 16 | .... | 604 | 622 | 642 | 666 | 692 |
| | | | | | 18 | .... | 610 | 630 | 653 | 679 | 709 |
| | | | | | 20 | .... | 616 | 638 | 664 | 693 | 726 |
| | | | | | 22 | 601 | 622 | 647 | 675 | 707 | |
| | | 7/0 | 1½ | 1.80 | 12 | .... | .... | | .... | 834 | 854 |
| | | | | | 14 | .... | .... | .... | 827 | 848 | 871 |
| | | | | | 16 | .... | .... | .... | 838 | 862 | 888 |
| | | | | | 18 | .... | .... | .... | 849 | 876 | 905 |
| | | | | | 20 | .... | | 835 | 860 | 890 | 922 |
| | | | | | 22 | .... | .... | 843 | 871 | 904 | |
| 33 | 29 | 6/0 | 2¼ | 1 | 12 | .... | .... | 645 | 660 | 678 | 697 |
| | | | | | 14 | .... | .... | 653 | 671 | 692 | 715 |
| | | | | | 16 | .... | 644 | 662 | 682 | 706 | 732 |
| | | | | | 18 | .... | 650 | 670 | 693 | 720 | 749 |
| | | | | | 20 | .... | 656 | 679 | 704 | 734 | 766 |
| | | | | | 22 | 642 | 662 | 687 | 715 | 747 | |
| | | 7/0 | 1½ | 1.73 | 12 | .... | .... | .... | .... | 869 | 889 |
| | | | | | 14 | .... | .... | .... | .... | 883 | 906 |
| | | | | | 16 | .... | .... | .... | 874 | 897 | 923 |
| | | | | | 18 | .... | .... | .... | 885 | 911 | 940 |
| | | | | | 20 | .... | .... | 870 | 896 | 925 | 958 |
| | | | | | 22 | .... | .... | 878 | 907 | 939 | |
| 34 | 30 | 6/0 | 2¼ | 1 | 12 | .... | .... | 687 | 702 | 720 | 739 |
| | | | | | 14 | .... | .... | 695 | 713 | 734 | 756 |
| | | | | | 16 | .... | 686 | 704 | 724 | 748 | 774 |
| | | | | | 18 | .... | 692 | 712 | 735 | 761 | 791 |
| | | | | | 20 | .... | 698 | 720 | 746 | 775 | 808 |
| | | | | | 22 | .... | 704 | 729 | 757 | 789 | 825 |
| | | | | | 24 | 688 | 710 | 737 | 768 | 803 | |
| | | 7/0 | 1½ | 1.67 | 12 | .... | .... | .... | .... | 908 | 928 |
| | | | | | 14 | .... | .... | .... | .... | 922 | 945 |
| | | | | | 16 | .... | .... | .... | 913 | 936 | 962 |
| | | | | | 18 | .... | .... | .... | 924 | 950 | 980 |
| | | | | | 20 | .... | .... | 909 | 935 | 964 | 997 |
| | | | | | 22 | .... | .... | 917 | 946 | 978 | 1014 |
| | | | | | 24 | .... | .... | 926 | 957 | 992 | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS



$$P = Af_c[1+(n-1)p]+2f_s p'A$$

$$f_s = 20{,}000$$

$$Max.\left(\frac{length}{diameter}\right) = 15$$

*1:6 mixture*
$n = 15$
$f_c = 500$

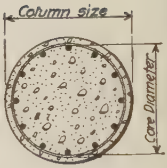
| Size of column (inches) | Diameter of core (inches) | Spirals: Size No. (A. S. & W. Co.) | Spirals: Pitch (inches) | Spirals: Per cent of core | Number of rods | Size of vertical round rods: ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | 31 | 6/0 | 2⅛ | 1 | 14 | .... | .... | 738 | 756 | 777 | 800 |
| | | | | | 16 | .... | .... | 747 | 767 | 791 | 817 |
| | | | | | 18 | .... | 735 | 755 | 778 | 805 | 834 |
| | | | | | 20 | .... | 741 | 763 | 789 | 818 | 851 |
| | | | | | 22 | .... | 747 | 772 | 800 | 832 | 868 |
| | | | | | 24 | .... | 754 | 780 | 811 | 846 | 885 |
| | | 7/0 | 1½ | 1.62 | 14 | .... | .... | .... | .... | 964 | 987 |
| | | | | | 16 | .... | .... | .... | 954 | 978 | 1004 |
| | | | | | 18 | .... | .... | .... | 965 | 992 | 1021 |
| | | | | | 20 | .... | .... | .... | 976 | 1006 | 1038 |
| | | | | | 22 | .... | .... | 959 | 987 | 1020 | 1055 |
| | | | | | 24 | .... | .... | 967 | 998 | 1033 | 1073 |
| 36 | 32 | 6/0 | 2 | 1 | 14 | .... | .... | 783 | 801 | 821 | 844 |
| | | | | | 16 | .... | .... | 791 | 812 | 835 | 861 |
| | | | | | 18 | .... | .... | 799 | 823 | 849 | 878 |
| | | | | | 20 | .... | 786 | 808 | 834 | 863 | 896 |
| | | | | | 22 | .... | 792 | 816 | 845 | 877 | 913 |
| | | | | | 24 | .... | 798 | 825 | 856 | 891 | 930 |
| | | 7/0 | 1½ | 1.57 | 14 | .... | .... | .... | .... | 1003 | 1026 |
| | | | | | 16 | .... | .... | .... | 994 | 1017 | 1043 |
| | | | | | 18 | .... | .... | .... | 1005 | 1031 | 1060 |
| | | | | | 20 | .... | .... | .... | 1016 | 1045 | 1078 |
| | | | | | 22 | .... | .... | 999 | 1026 | 1059 | 1095 |
| | | | | | 24 | .... | .... | 1007 | 1038 | 1073 | 1112 |
| 37 | 33 | 7/0 | 2¼ | 1 | 14 | .... | .... | .... | 847 | 867 | 890 |
| | | | | | 16 | .... | .... | 837 | 858 | 881 | 907 |
| | | | | | 18 | .... | .... | 845 | 869 | 895 | 924 |
| | | | | | 20 | .... | 832 | 854 | 880 | 909 | 942 |
| | | | | | 22 | .... | 838 | 862 | 891 | 923 | 959 |
| | | | | | 24 | .... | 844 | 871 | 902 | 937 | 976 |
| | | | | | 26 | .... | 850 | 879 | 913 | 951 | 993 |
| | | 7/0 | 1½ | 1.52 | 14 | .... | .... | .... | .... | 1043 | 1066 |
| | | | | | 16 | .... | .... | .... | .... | 1057 | 1083 |
| | | | | | 18 | .... | .... | .... | 1045 | 1071 | 1101 |
| | | | | | 20 | .... | .... | .... | 1056 | 1085 | 1118 |
| | | | | | 22 | .... | .... | 1039 | 1067 | 1099 | 1135 |
| | | | | | 24 | .... | .... | 1047 | 1078 | 1113 | 1152 |
| | | | | | 26 | .... | .... | 1055 | 1089 | 1127 | 1169 |
| 38 | 34 | 7/0 | 2⅛ | 1 | 14 | .... | .... | .... | 894 | 915 | 937 |
| | | | | | 16 | .... | .... | 884 | 905 | 928 | 955 |
| | | | | | 18 | .... | .... | 893 | 916 | 942 | 972 |
| | | | | | 20 | .... | .... | 901 | 927 | 956 | 989 |
| | | | | | 22 | .... | 885 | 909 | 938 | 970 | 1006 |
| | | | | | 24 | .... | 891 | 918 | 949 | 984 | 1023 |
| | | | | | 26 | .... | 898 | 927 | 960 | 998 | 1040 |
| | | 7/0 | 1½ | 1.48 | 14 | .... | .... | .... | .... | 1088 | 1111 |
| | | | | | 16 | .... | .... | .... | .... | 1102 | 1128 |
| | | | | | 18 | .... | .... | .... | 1090 | 1116 | 1146 |
| | | | | | 20 | .... | .... | .... | 1101 | 1130 | 1163 |
| | | | | | 22 | .... | .... | .... | 1112 | 1144 | 1180 |
| | | | | | 24 | .... | .... | 1092 | 1123 | 1158 | 1197 |
| | | | | | 26 | .... | .... | 1100 | 1134 | 1171 | 1214 |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

$$P = Af_c[1 + (n-1)p] + 2f_s p'A$$

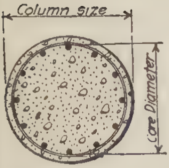
$$f_s = 20{,}000$$

$$Max.\left(\frac{length}{diameter}\right) = 15$$



*1:6 mixture*
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals: Size No. (A. S. & W. Co.) | Spirals: Pitch (inches) | Spirals: Per cent of core | Number of rods | Size of vertical round rods: 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 35 | 7/0 | 2 1/8 | 1 | 14 | .... | .... | .... | 943 | 963 | 986 |
| | | | | | 16 | ... | ... | 933 | 954 | 977 | 1003 |
| | | | | | 18 | . | .... | 942 | 964 | 991 | 1020 |
| | | | | | 20 | .. | .... | 950 | 975 | 1005 | 1038 |
| | | | | | 22 | .. | 934 | 958 | 986 | 1019 | 1055 |
| | | | | | 24 | .. | 940 | 967 | 997 | 1033 | 1071 |
| | | | | | 26 | ... | 946 | 975 | 1008 | 1047 | 1089 |
| | | 7/0 | 1 1/2 | 1.43 | 14 | .... | .. | .... | .... | 1129 | 1152 |
| | | | | | 16 | ... | .... | .... | .... | 1143 | 1169 |
| | | | | | 18 | .. | ... | .... | 1130 | 1157 | 1187 |
| | | | | | 20 | ... | .... | .... | 1141 | 1171 | 1204 |
| | | | | | 22 | | .... | .... | 1152 | 1185 | 1221 |
| | | | | | 24 | | ... | 1133 | 1164 | 1199 | 1238 |
| | | | | | 26 | . | . | 1141 | 1175 | 1213 | 1255 |
| 40 | 36 | 7/0 | 2 | 1 | 16 | .. | ... | .... | 1005 | 1028 | 1055 |
| | | | | | 18 | | | 992 | 1016 | 1042 | 1072 |
| | | | | | 20 | | | 1001 | 1027 | 1056 | 1089 |
| | | | | | 22 | | | 1010 | 1038 | 1070 | 1106 |
| | | | | | 24 | | 990 | 1018 | 1049 | 1084 | 1123 |
| | | | | | 26 | . | 997 | 1027 | 1060 | 1098 | 1140 |
| | | | | | 28 | | 1004 | 1035 | 1071 | 1112 | 1158 |
| | | 7/0 | 1 1/2 | 1.40 | 16 | .. | . | .... | .... | 1190 | 1216 |
| | | | | | 18 | .... | ... | .... | .... | 1204 | 1234 |
| | | | | | 20 | .. | ... | .... | 1189 | 1218 | 1251 |
| | | | | | 22 | ... | ... | .... | 1200 | 1232 | 1268 |
| | | | | | 24 | .. | ... | 1180 | 1211 | 1246 | 1285 |
| | | | | | 26 | . | .... | 1188 | 1222 | 1260 | 1302 |
| | | | | | 28 | . | .. | 1197 | 1233 | 1274 | 1320 |
| 41 | 37 | 7/0 | 2 | 1 | 16 | ... | .... | .... | 1056 | 1079 | 1105 |
| | | | | | 18 | .. | ... | 1043 | 1067 | 1093 | 1122 |
| | | | | | 20 | ... | ... | 1052 | 1078 | 1107 | 1139 |
| | | | | | 22 | .. | .. | 1060 | 1089 | 1121 | 1157 |
| | | | | | 24 | ... | 1042 | 1069 | 1100 | 1135 | 1174 |
| | | | | | 26 | ... | 1048 | 1077 | 1111 | 1149 | 1191 |
| | | | | | 28 | ... | 1054 | 1085 | 1122 | 1162 | 1208 |
| | | 7/0 | 1 1/2 | 1.36 | 16 | .... | .... | .... | .... | 1233 | 1259 |
| | | | | | 18 | ... | .. | .... | .... | 1247 | 1277 |
| | | | | | 20 | .... | .... | .... | 1232 | 1261 | 1294 |
| | | | | | 22 | .. | ... | .... | 1243 | 1275 | 1311 |
| | | | | | 24 | .... | .. | ... | 1254 | 1289 | 1328 |
| | | | | | 26 | .. | .... | 1231 | 1265 | 1303 | 1345 |
| | | | | | 28 | .... | .... | 1240 | 1276 | 1317 | 1362 |



## ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

$$P = Af_c[1+(n-1)p]+2f_sp'A$$

$$f_s = 20{,}000$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 15$$

1:6 mixture
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | 5/8 | 3/4 | 7/8 | 1 | 1⅛ | 1¼ |
| 42 | 38 | 7/0 | 2 | 1 | 16 |  |  | ... | 1109 | 1132 | 1158 |
|  |  |  |  |  | 18 |  | ... | .... | 1120 | 1146 | 1175 |
|  |  |  |  |  | 20 |  | ... | 1105 | 1131 | 1160 | 1192 |
|  |  |  |  |  | 22 | .. | .... | 1113 | 1142 | 1174 | 1210 |
|  |  |  |  |  | 24 | . | .... | 1122 | 1153 | 1188 | 1227 |
|  |  |  |  |  | 26 |  | 1101 | 1130 | 1164 | 1202 | 1244 |
|  |  |  |  |  | 28 |  | 1107 | 1138 | 1175 | 1215 | 1261 |
|  |  |  |  |  | 30 |  | 1113 | 1147 | 1186 | 1229 | 1278 |
|  |  | 7/0 | 1½ | 1.32 | 16 |  | ... | .... | .... | 1277 | 1303 |
|  |  |  |  |  | 18 |  | .... | .... | .... | 1291 | 1321 |
|  |  |  |  |  | 20 | . | ... | .... | 1276 | 1305 | 1338 |
|  |  |  |  |  | 22 | . | ... | .... | 1287 | 1319 | 1355 |
|  |  |  |  |  | 24 | . | .... | .... | 1298 | 1333 | 1372 |
|  |  |  |  |  | 26 |  | .. | 1275 | 1309 | 1347 | 1389 |
|  |  |  |  |  | 28 |  | ... | 1284 | 1320 | 1361 | 1407 |
|  |  |  |  |  | 30 | .. | ... | 1292 | 1331 | 1375 | 1424 |
| 43 | 39 | 7/0 | 1⅞ | 1 | 16 | . | ... | .... | 1163 | 1186 | 1212 |
|  |  |  |  |  | 18 | .. | ... | .... | 1174 | 1200 | 1230 |
|  |  |  |  |  | 20 | .. | .... | 1159 | 1185 | 1214 | 1247 |
|  |  |  |  |  | 22 | . | .. | 1168 | 1196 | 1228 | 1264 |
|  |  |  |  |  | 24 | ... | .. | 1176 | 1207 | 1242 | 1282 |
|  |  |  |  |  | 26 | ... | .... | 1185 | 1218 | 1256 | 1298 |
|  |  |  |  |  | 28 |  | 1162 | 1193 | 1229 | 1270 | 1316 |
|  |  |  |  |  | 30 | .. | 1168 | 1201 | 1240 | 1284 | 1333 |
|  |  | 7/0 | 1½ | 1.29 | 16 | .... | .... | .... | .... | 1323 | 1349 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1337 | 1367 |
|  |  |  |  |  | 20 | ... | .... | .... | 1322 | 1351 | 1384 |
|  |  |  |  |  | 22 | ... | .. | .... | 1333 | 1365 | 1401 |
|  |  |  |  |  | 24 | ... | ... | .... | 1344 | 1379 | 1418 |
|  |  |  |  |  | 26 | ... | .. | 1321 | 1355 | 1392 | 1435 |
|  |  |  |  |  | 28 | .. | ... | 1330 | 1366 | 1407 | 1453 |
|  |  |  |  |  | 30 | ... | ... | 1338 | 1377 | 1421 | 1470 |
| 44 | 40 | 7/0 | 1⅞ | 1 | 16 | .... | .. | .... | 1219 | 1242 | 1268 |
|  |  |  |  |  | 18 | ... | .. | .... | 1230 | 1256 | 1286 |
|  |  |  |  |  | 20 | .. |  | .... | 1241 | 1270 | 1303 |
|  |  |  |  |  | 22 | .. | . | 1224 | 1252 | 1284 | 1320 |
|  |  |  |  |  | 24 |  | . | 1232 | 1263 | 1298 | 1337 |
|  |  |  |  |  | 26 | . | ... | 1240 | 1274 | 1312 | 1354 |
|  |  |  |  |  | 28 |  | 1217 | 1249 | 1285 | 1326 | 1371 |
|  |  |  |  |  | 30 | . | 1224 | 1257 | 1296 | 1340 | 1389 |
|  |  | 7/0 | 1½ | 1.25 | 16 | . | . | .... | .... | 1367 | 1393 |
|  |  |  |  |  | 18 |  |  | .... | .... | 1381 | 1411 |
|  |  |  |  |  | 20 |  | . | .... | 1366 | 1395 | 1428 |
|  |  |  |  |  | 22 |  | . | .... | 1377 | 1409 | 1445 |
|  |  |  |  |  | 24 |  | . | .... | 1388 | 1423 | 1462 |
|  |  |  |  |  | 26 | .. |  | .... | 1399 | 1437 | 1479 |
|  |  |  |  |  | 28 | . | .. | 1374 | 1410 | 1451 | 1497 |
|  |  |  |  |  | 30 | .. | .... | 1382 | 1421 | 1465 | 1514 |

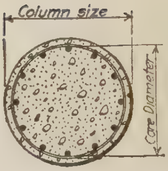
# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

$$P = Af_c[1+(n-1)p]+2f_s p'A$$

$$f_s = 20{,}000$$

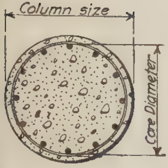
$$Max.\left(\frac{length}{diameter}\right) = 15$$

**1:4½ mixture**
$n = 12$
$f_c = 600$



| Size of column (inches) | Diameter of core (inches) | Spirals: Size No. (A. S. & W. Co.) | Spirals: Pitch (inches) | Spirals: Per cent of core | Number of rods | Size of vertical round rods: ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 8 | 6 | 1¼ | 1 | 6 | 62 | | | | | |
| 13 | 9 | 5 | 1½ | 1 | 6 | 76 | | | | | |
| | | | | | 8 | 80 | | | | | |
| 14 | 10 | 4 | 1½ | 1 | 6 | 91 | 96 | | | | |
| | | | | | 8 | 95 | | | | | |
| 15 | 11 | 3 | 1⅝ | 1 | 6 | 107 | 112 | 119 | | | |
| | | | | | 8 | 111 | 118 | | | | |
| | | | | | 10 | 115 | | | | | |
| 16 | 12 | 2 | 1¾ | 1 | 6 | 125 | 131 | 137 | | | |
| | | | | | 8 | 129 | 136 | | | | |
| | | | | | 10 | 133 | 142 | | | | |
| | | 3/0 | 1⅝ | 2 | 6 | .... | 176 | 182 | | | |
| | | | | | 8 | 175 | 182 | | | | |
| | | | | | 10 | 179 | 187 | | | | |
| 17 | 13 | 1 | 1¾ | 1 | 6 | 145 | 150 | 157 | 164 | | |
| | | | | | 8 | 149 | 156 | 164 | | | |
| | | | | | 10 | 153 | 162 | | | | |
| | | 4/0 | 1⅞ | 2 | 6 | .... | 203 | 210 | 217 | | |
| | | | | | 8 | .... | 209 | 217 | | | |
| | | | | | 10 | 206 | 215 | | | | |
| 18 | 14 | 1 | 1¾ | 1 | 6 | 166 | 171 | 178 | 185 | | |
| | | | | | 8 | 170 | 177 | 186 | | | |
| | | | | | 10 | 174 | 183 | 194 | | | |
| | | | | | 12 | 178 | 189 | | | | |
| | | 4/0 | 1¾ | 2 | 6 | .... | .... | 239 | 247 | | |
| | | | | | 8 | .... | 239 | 247 | | | |
| | | | | | 10 | 236 | 245 | 255 | | | |
| | | | | | 12 | 240 | 250 | | | | |
| 19 | 15 | 0 | 1⅞ | 1 | 6 | 189 | 194 | 201 | 208 | 216 | |
| | | | | | 8 | 193 | 200 | 208 | 218 | | |
| | | | | | 10 | 197 | 206 | 216 | | | |
| | | | | | 12 | 201 | 212 | | | | |
| | | 5/0 | 1⅞ | 2 | 6 | .... | .... | 271 | 278 | 287 | |
| | | | | | 8 | .... | 271 | 279 | 289 | | |
| | | | | | 10 | .... | 276 | 287 | | | |
| | | | | | 12 | 272 | 282 | | | | |
| 20 | 16 | 2/0 | 2⅛ | 1 | 8 | 217 | 224 | 233 | 243 | 254 | |
| | | | | | 10 | 221 | 230 | 241 | 253 | | |
| | | | | | 12 | 225 | 236 | 249 | | | |
| | | | | | 14 | 229 | 242 | | | | |
| | | 6/0 | 2 | 2 | 8 | .... | .... | 313 | 323 | 334 | |
| | | | | | 10 | .... | 311 | 321 | 333 | | |
| | | | | | 12 | .... | 316 | 329 | | | |
| | | | | | 14 | 310 | 322 | | | | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS



$$P = Af_c[1+(n-1)p]+2f_s p'A$$

$$f_s = 20{,}000$$

$$\text{Max.}\left(\frac{length}{diameter}\right) = 15$$

*1:4½ mixture*
$n = 12$
$f_c = 600$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 21 | 17 | 2/0 | 2 | 1 | 8 | 243 | 250 | 259 | 268 | 279 | |
| | | | | | 10 | 247 | 256 | 267 | 289 | | |
| | | | | | 12 | 251 | 262 | 275 | | | |
| | | | | | 14 | 255 | 268 | 283 | | | |
| | | 6/0 | 1⅞ | 2 | 8 | .... | .... | 350 | 359 | 370 | |
| | | | | | 10 | .... | .... | 357 | 370 | | |
| | | | | | 12 | .... | 353 | 365 | | | |
| | | | | | 14 | .... | 359 | 373 | | | |
| 22 | 18 | 3/0 | 2¼ | 1 | 8 | .... | 278 | 286 | 296 | 307 | 319 |
| | | | | | 10 | 275 | 284 | 294 | 306 | 320 | |
| | | | | | 12 | 279 | 289 | 302 | 317 | | |
| | | | | | 14 | 283 | 295 | 310 | | | |
| | | 7/0 | 2 | 2 | 8 | .... | .... | .... | 398 | 409 | 421 |
| | | | | | 10 | .... | .... | 396 | 408 | 422 | |
| | | | | | 12 | .... | 391 | 404 | 419 | | |
| | | | | | 14 | ... | 397 | 412 | | | |
| 23 | 19 | 3/0 | 2⅛ | 1 | 8 | .... | 307 | 315 | 325 | 336 | 348 |
| | | | | | 10 | 304 | 313 | 323 | 335 | 349 | |
| | | | | | 12 | 308 | 318 | 331 | 346 | | |
| | | | | | 14 | 312 | 324 | 339 | 366 | | |
| | | | | | 16 | 316 | 330 | 347 | | | |
| | | 7/0 | 1⅞ | 2 | 8 | .... | .... | .... | 438 | 449 | 462 |
| | | | | | 10 | .... | .... | 437 | 449 | 463 | |
| | | | | | 12 | .... | .... | 445 | 459 | | |
| | | | | | 14 | .... | 438 | 452 | 469 | | |
| | | | | | 16 | .... | 444 | 460 | | | |
| 24 | 20 | 3/0 | 2 | 1 | 8 | .... | 337 | 346 | 356 | 367 | 379 |
| | | | | | 10 | .... | 343 | 354 | 366 | 380 | 395 |
| | | | | | 12 | 338 | 349 | 362 | 376 | 393 | |
| | | | | | 14 | 343 | 355 | 370 | 387 | | |
| | | | | | 16 | 347 | 361 | 378 | 397 | | |
| | | 7/0 | 1⅞ | 2 | 8 | .... | .... | .... | 481 | 492 | 505 |
| | | | | | 10 | .... | .... | .... | 492 | 505 | 521 |
| | | | | | 12 | .... | .... | 487 | 502 | 519 | |
| | | | | | 14 | .... | .... | 495 | 512 | | |
| | | | | | 16 | .... | 486 | 503 | 523 | | |
| 25 | 21 | 4/0 | 2¼ | 1 | 10 | .... | 376 | 386 | 398 | 412 | 427 |
| | | | | | 12 | 371 | 381 | 394 | 409 | 425 | |
| | | | | | 14 | 375 | 387 | 402 | 419 | | |
| | | | | | 16 | 379 | 393 | 410 | 429 | | |
| | | 7/0 | 1¾ | 2 | 10 | .... | .... | .... | 537 | 551 | 566 |
| | | | | | 12 | .... | .... | 533 | 547 | 564 | |
| | | | | | 14 | .... | .... | 540 | 557 | | |
| | | | | | 16 | .... | 532 | 548 | 568 | | |

**COLUMNS**

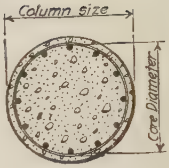
# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

$$P = Af_c[1+(n-1)p]+2f_s p'A$$

$$f_s = 20{,}000$$

$$Max. \left(\frac{length}{diameter}\right) = 15$$

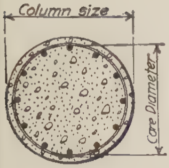
*1:4½ mixture*
$n = 12$
$f_c = 600$



| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 26 | 22 | 4/0 | 2⅛ | 1 | 10 | . | 409 | 420 | 432 | 446 | 461 |
| | | | | | 12 | . . | 415 | 428 | 442 | 459 | 477 |
| | | | | | 14 | 408 | 421 | 436 | 453 | 472 | |
| | | | | | 16 | 412 | 427 | 414 | 463 | | |
| | | | | | 18 | 417 | 433 | 452 | 473 | | |
| | | 7/0 | 1⅝ | 2 | 10 | . . | . | . | 584 | 598 | 613 |
| | | | | | 12 | | | . | 594 | 611 | 629 |
| | | | | | 14 | . | . | 588 | 605 | 624 | |
| | | | | | 16 | . | | 596 | 615 | | |
| | | | | | 18 | . | 585 | 604 | 625 | | |
| 27 | 23 | 4/0 | 2⅛ | 1 | 10 | . . . | 445 | 455 | 467 | 481 | 496 |
| | | | | | 12 | . . | 450 | 463 | 478 | 494 | 513 |
| | | | | | 14 | 444 | 456 | 471 | 488 | 507 | |
| | | | | | 16 | 448 | 462 | 479 | 498 | 520 | |
| | | | | | 18 | 452 | 468 | 487 | 509 | | |
| | | 7/0 | 1⅝ | 2 | 10 | . . . | . . . | . . . . | . . . . | 647 | 663 |
| | | | | | 12 | . . . . | . . . | . . | 644 | 660 | 679 |
| | | | | | 14 | . . . . | . . | 637 | 654 | 673 | |
| | | | | | 16 | . . . . | | 645 | 665 | 686 | |
| | | | | | 18 | . | . | 653 | 675 | | |
| 28 | 24 | 4/0 | 2 | 1 | 10 | . . | | 492 | 504 | 518 | 533 |
| | | | | | 12 | . | 487 | 500 | 515 | 531 | 550 |
| | | | | | 14 | . | 493 | 508 | 525 | 544 | 566 |
| | | | | | 16 | 485 | 499 | 516 | 535 | 557 | |
| | | | | | 18 | 489 | 505 | 524 | 546 | 570 | |
| | | 7/0 | 1½ | 2 | 10 | . . . . | . . . . | . . . | . . . | 699 | 714 |
| | | | | | 12 | . | . . . . | . . . . | 696 | 712 | 730 |
| | | | | | 14 | . | . . . | . | 706 | 725 | 747 |
| | | | | | 16 | . . . | . . . . | 697 | 716 | 738 | |
| | | | | | 18 | . | . | 705 | 727 | 751 | |
| 29 | 25 | 5/0 | 2¼ | 1 | 10 | . . | . . . | 531 | 543 | 557 | 572 |
| | | | | | 12 | . . | 526 | 539 | 553 | 570 | 588 |
| | | | | | 14 | . . | 532 | 546 | 563 | 583 | 604 |
| | | | | | 16 | 523 | 538 | 554 | 574 | 596 | 620 |
| | | | | | 18 | 527 | 543 | 562 | 584 | 609 | |
| | | | | | 20 | 531 | 549 | 570 | 595 | | |
| | | 7/0 | 1½ | 2 | 10 | . . . . | . . . . | . . . . | . . . . | 753 | 768 |
| | | | | | 12 | . . . | . . . | . . . . | . . . | 766 | 784 |
| | | | | | 14 | . . . | . . . . | . . . . | 760 | 779 | 801 |
| | | | | | 16 | . . | . . . . | . . . . | 770 | 792 | 817 |
| | | | | | 18 | . . | . . . . | 759 | 781 | 805 | |
| | | | | | 20 | . . . | . . . . | 767 | 791 | | |
| 30 | 26 | 5/0 | 2¼ | 1 | 12 | . | 566 | 579 | 593 | 610 | 628 |
| | | | | | 14 | . . | 572 | 586 | 603 | 623 | 644 |
| | | | | | 16 | . . . . | 578 | 594 | 614 | 636 | 660 |
| | | | | | 18 | 567 | 583 | 602 | 624 | 649 | |
| | | | | | 20 | 571 | 589 | 610 | 635 | 662 | |
| | | 7/0 | 1½ | 1.93 | 12 | . . . . | . . . . | . . . | . . . . | 807 | 825 |
| | | | | | 14 | . . . . | . . . . | . . . . | 800 | 820 | 841 |
| | | | | | 16 | . . . . | . . . . | . . . . | 811 | 833 | 857 |
| | | | | | 18 | . . . . | . . . . | 799 | 821 | 846 | |
| | | | | | 20 | . . . . | . . . . | 807 | 832 | 859 | |

TABLE 39

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS



$$P = Af_c[1+(n-1)p]+2f_s p'A$$

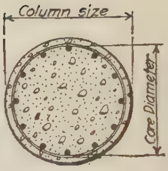
$$f_s = 20{,}000$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 15$$

*1:4½ mixture*
$n = 12$
$f_c = 600$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 31 | 27 | 5/0 | 2⅛ | 1 | 12 | .... | .... | 620 | 635 | 651 | 670 |
| | | | | | 14 | .... | 613 | 628 | 645 | 664 | 686 |
| | | | | | 16 | .... | 619 | 636 | 656 | 678 | 702 |
| | | | | | 18 | .... | 625 | 644 | 666 | 691 | 718 |
| | | | | | 20 | 613 | 631 | 652 | 676 | 704 | |
| | | | | | 22 | 617 | 637 | 660 | 687 | 717 | |
| | | 7/0 | 1½ | 1.86 | 12 | .... | .... | .... | .... | 848 | 867 |
| | | | | | 14 | .... | .... | .... | 842 | 861 | 883 |
| | | | | | 16 | .... | .... | .... | 853 | 875 | 899 |
| | | | | | 18 | .... | .... | 841 | 863 | 888 | 915 |
| | | | | | 20 | .... | .... | 849 | 873 | 901 | |
| | | | | | 22 | .... | .... | 857 | 884 | 914 | |
| 32 | 28 | 5/0 | 2 | 1 | 12 | .... | .... | 663 | 678 | 695 | 713 |
| | | | | | 14 | .... | 657 | 671 | 688 | 708 | 729 |
| | | | | | 16 | .... | 662 | 679 | 699 | 721 | 745 |
| | | | | | 18 | .... | 668 | 687 | 709 | 734 | 762 |
| | | | | | 20 | .... | 674 | 695 | 719 | 747 | 778 |
| | | | | | 22 | 660 | 680 | 703 | 730 | 760 | |
| | | 7/0 | 1½ | 1.80 | 12 | .... | .... | .... | .... | 892 | 910 |
| | | | | | 14 | .... | .... | .... | 885 | 905 | 926 |
| | | | | | 16 | .... | .... | .... | 896 | 918 | 942 |
| | | | | | 18 | .... | .... | .... | 906 | 931 | 959 |
| | | | | | 20 | .... | .... | 892 | 916 | 944 | 975 |
| | | | | | 22 | .... | .... | 900 | 927 | 957 | |
| 33 | 29 | 6/0 | 2¼ | 1 | 12 | .... | .... | 708 | 723 | 739 | 758 |
| | | | | | 14 | .... | .... | 716 | 733 | 752 | 774 |
| | | | | | 16 | .... | 707 | 724 | 743 | 765 | 790 |
| | | | | | 18 | .... | 713 | 732 | 754 | 778 | 806 |
| | | | | | 20 | .... | 719 | 740 | 764 | 792 | 822 |
| | | | | | 22 | 705 | 725 | 748 | 775 | 805 | |
| | | 7/0 | 1½ | 1.73 | 12 | .... | .... | .... | .... | 932 | 951 |
| | | | | | 14 | .... | .... | .... | .... | 945 | 967 |
| | | | | | 16 | .... | .... | .... | 936 | 958 | 983 |
| | | | | | 18 | .... | .... | .... | 947 | 971 | 999 |
| | | | | | 20 | .... | .... | 934 | 957 | 985 | 1015 |
| | | | | | 22 | .... | .... | 941 | 967 | 998 | |
| 34 | 30 | 6/0 | 2¼ | 1 | 12 | .... | .... | 755 | 769 | 786 | 804 |
| | | | | | 14 | .... | .... | 762 | 779 | 799 | 820 |
| | | | | | 16 | .... | 754 | 770 | 790 | 812 | 836 |
| | | | | | 18 | .... | 759 | 778 | 800 | 825 | 853 |
| | | | | | 20 | .... | 765 | 786 | 811 | 838 | 869 |
| | | | | | 22 | .... | 771 | 794 | 821 | 851 | 885 |
| | | | | | 24 | 755 | 777 | 802 | 831 | 864 | |
| | | 7/0 | 1½ | 1.67 | 12 | .... | .... | .... | .... | 975 | 994 |
| | | | | | 14 | .... | .... | .... | .... | 988 | 1010 |
| | | | | | 16 | .... | .... | .... | 979 | 1001 | 1026 |
| | | | | | 18 | .... | .... | .... | 990 | 1014 | 1042 |
| | | | | | 20 | .... | .... | 976 | 1000 | 1028 | 1058 |
| | | | | | 22 | .... | .... | 984 | 1010 | 1041 | 1075 |
| | | | | | 24 | .... | .... | 992 | 1021 | 1054 | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

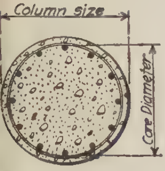


$$P = Af_c[1+(n-1)p]+2f_sp'A$$
$$f_s = 20,000$$
$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 15$$

*1:4½ mixture*
$n = 12$
$f_c = 600$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 35 | 31 | 6/0 | 2⅛ | 1 | 14 | .... | .... | 810 | 827 | 847 | 868 |
| | | | | | 16 | .... | .... | 818 | 838 | 860 | 884 |
| | | | | | 18 | .... | 807 | 826 | 848 | 873 | 901 |
| | | | | | 20 | .... | 813 | 834 | 858 | 886 | 917 |
| | | | | | 22 | .... | 819 | 842 | 869 | 899 | 933 |
| | | | | | 24 | .... | 825 | 850 | 879 | 912 | 949 |
| | | 7/0 | 1½ | 1.62 | 14 | .... | .... | .... | .... | 1034 | 1055 |
| | | | | | 16 | .... | .... | .... | 1025 | 1047 | 1072 |
| | | | | | 18 | .... | .... | .... | 1035 | 1060 | 1088 |
| | | | | | 20 | .... | .... | .... | 1046 | 1073 | 1104 |
| | | | | | 22 | .... | .... | 1029 | 1056 | 1086 | 1120 |
| | | | | | 24 | .... | .... | 1037 | 1066 | 1099 | 1136 |
| 36 | 32 | 6/0 | 2 | 1 | 14 | .... | .... | 860 | 877 | 896 | 918 |
| | | | | | 16 | .... | .... | 868 | 887 | 909 | 934 |
| | | | | | 18 | .... | .... | 876 | 898 | 922 | 950 |
| | | | | | 20 | .... | 863 | 884 | 908 | 935 | 966 |
| | | | | | 22 | .... | 868 | 892 | 918 | 949 | 982 |
| | | | | | 24 | .... | 874 | 899 | 929 | 962 | 999 |
| | | 7/0 | 1½ | 1.57 | 14 | .... | .... | .... | .... | 1079 | 1101 |
| | | | | | 16 | .... | .... | .... | 1070 | 1092 | 1117 |
| | | | | | 18 | .... | .... | .... | 1081 | 1106 | 1133 |
| | | | | | 20 | .... | .... | .... | 1091 | 1119 | 1149 |
| | | | | | 22 | .... | .... | 1075 | 1102 | 1132 | 1166 |
| | | | | | 24 | .... | .... | 1083 | 1112 | 1145 | 1182 |
| 37 | 33 | 7/0 | 2¼ | 1 | 14 | .... | .... | .... | 928 | 947 | 969 |
| | | | | | 16 | .... | .... | 919 | 938 | 960 | 985 |
| | | | | | 18 | .... | .... | 927 | 949 | 973 | 1001 |
| | | | | | 20 | .... | 914 | 935 | 959 | 987 | 1017 |
| | | | | | 22 | .... | 919 | 943 | 969 | 1000 | 1033 |
| | | | | | 24 | .... | 925 | 951 | 980 | 1013 | 1050 |
| | | | | | 26 | .... | 931 | 958 | 990 | 1026 | 1066 |
| | | 7/0 | 1½ | 1.52 | 14 | .... | .... | .... | .... | 1125 | 1146 |
| | | | | | 16 | .... | .... | .... | .... | 1138 | 1163 |
| | | | | | 18 | .... | .... | .... | 1126 | 1151 | 1179 |
| | | | | | 20 | .... | .... | .... | 1137 | 1164 | 1195 |
| | | | | | 22 | .... | .... | 1120 | 1147 | 1177 | 1211 |
| | | | | | 24 | .... | .... | 1128 | 1157 | 1190 | 1227 |
| | | | | | 26 | .... | .... | 1136 | 1168 | 1204 | 1243 |
| 38 | 34 | 7/0 | 2⅛ | 1 | 14 | .... | .... | .... | 980 | 1000 | 1021 |
| | | | | | 16 | .... | .... | 971 | 991 | 1013 | 1037 |
| | | | | | 18 | .... | .... | 979 | 1001 | 1026 | 1054 |
| | | | | | 20 | .... | .... | 987 | 1012 | 1039 | 1070 |
| | | | | | 22 | .... | 972 | 995 | 1022 | 1052 | 1086 |
| | | | | | 24 | .... | 978 | 1003 | 1032 | 1065 | 1102 |
| | | | | | 26 | .... | 984 | 1011 | 1043 | 1078 | 1118 |
| | | 7/0 | 1½ | 1.48 | 14 | .... | .... | .... | .... | 1174 | 1196 |
| | | | | | 16 | .... | .... | .... | .... | 1187 | 1212 |
| | | | | | 18 | .... | .... | .... | 1176 | 1200 | 1228 |
| | | | | | 20 | .... | .... | .... | 1186 | 1214 | 1244 |
| | | | | | 22 | .... | .... | .... | 1196 | 1227 | 1261 |
| | | | | | 24 | .... | .... | 1178 | 1207 | 1240 | 1277 |
| | | | | | 26 | .... | .... | 1186 | 1217 | 1253 | 1293 |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS



$$P = Af_c[1+(n-1)p] + 2f_c p'A$$

$$f_s = 20{,}000$$

$$Max.\left(\frac{length}{diameter}\right) = 15$$

*1:4½ mixture*
$n = 12$
$f_c = 600$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 39 | 35 | 7/0 | 2⅛ | 1 | 14 | .... | .... | .... | 1035 | 1054 | 1075 |
| | | | | | 16 | .... | .... | 1026 | 1045 | 1067 | 1092 |
| | | | | | 18 | .... | .... | 1034 | 1055 | 1080 | 1108 |
| | | | | | 20 | .... | .... | 1041 | 1066 | 1093 | 1124 |
| | | | | | 22 | .... | 1026 | 1049 | 1076 | 1106 | 1140 |
| | | | | | 24 | .... | 1032 | 1057 | 1087 | 1120 | 1156 |
| | | | | | 26 | .... | 1038 | 1065 | 1097 | 1133 | 1173 |
| | | 7/0 | 1½ | 1.43 | 14 | .... | .... | .... | .... | 1219 | 1240 |
| | | | | | 16 | .... | .... | .... | .... | 1232 | 1257 |
| | | | | | 18 | .... | .... | .... | 1220 | 1245 | 1273 |
| | | | | | 20 | .... | .... | .... | 1231 | 1258 | 1289 |
| | | | | | 22 | .... | .... | .... | 1241 | 1271 | 1305 |
| | | | | | 24 | .... | .... | 1222 | 1251 | 1284 | 1321 |
| | | | | | 26 | .... | .... | 1230 | 1262 | 1298 | 1338 |
| 40 | 36 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 1101 | 1123 | 1147 |
| | | | | | 18 | .... | .... | .... | 1111 | 1136 | 1164 |
| | | | | | 20 | .... | .... | 1097 | 1122 | 1149 | 1180 |
| | | | | | 22 | .... | .... | 1105 | 1132 | 1162 | 1196 |
| | | | | | 24 | .... | .... | 1113 | 1142 | 1175 | 1212 |
| | | | | | 26 | .... | 1094 | 1121 | 1153 | 1188 | 1228 |
| | | | | | 28 | .... | 1100 | 1129 | 1163 | 1202 | 1245 |
| | | 7/0 | 1½ | 1.40 | 16 | .... | .... | .... | .... | 1286 | 1311 |
| | | | | | 18 | .... | .... | .... | .... | 1299 | 1327 |
| | | | | | 20 | .... | .... | .... | 1284 | 1312 | 1343 |
| | | | | | 22 | .... | .... | .... | 1295 | 1325 | 1359 |
| | | | | | 24 | .... | .... | 1276 | 1305 | 1338 | 1375 |
| | | | | | 26 | .... | .... | 1284 | 1316 | 1352 | 1392 |
| | | | | | 28 | .... | .... | 1292 | 1326 | 1365 | 1408 |
| 41 | 37 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 1158 | 1180 | 1205 |
| | | | | | 18 | .... | .... | 1147 | 1169 | 1193 | 1221 |
| | | | | | 20 | .... | .... | 1155 | 1179 | 1206 | 1237 |
| | | | | | 22 | .... | .... | 1163 | 1189 | 1220 | 1253 |
| | | | | | 24 | .... | 1145 | 1170 | 1200 | 1233 | 1270 |
| | | | | | 26 | .... | 1151 | 1178 | 1210 | 1246 | 1286 |
| | | | | | 28 | .... | 1157 | 1186 | 1220 | 1259 | 1302 |
| | | 7/0 | 1½ | 1.36 | 16 | .... | .... | .... | .... | 1334 | 1359 |
| | | | | | 18 | .... | .... | .... | .... | 1347 | 1375 |
| | | | | | 20 | .... | .... | .... | 1333 | 1360 | 1391 |
| | | | | | 22 | .... | .... | .... | 1343 | 1373 | 1407 |
| | | | | | 24 | .... | .... | .... | 1353 | 1386 | 1423 |
| | | | | | 26 | .... | .... | 1332 | 1364 | 1399 | 1440 |
| | | | | | 28 | .... | .... | 1340 | 1374 | 1413 | 1456 |

**COLUMNS**

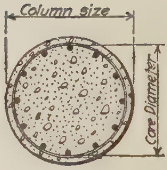
# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS NEW YORK CITY BUILDING CODE REQUIREMENTS

$$P = Af_c[1+(n-1)p]+2f_s p'A$$

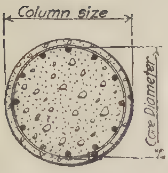
$$f_s = 20{,}000$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 15$$

*1:4½ mixture*
$n = 12$
$f_c = 600$



| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 42 | 38 | 7/0 | 2 | 1 | 16 | .... | .... | .... | 1217 | 1239 | 1264 |
|  |  |  |  |  | 18 | .... | .... | .... | 1227 | 1252 | 1280 |
|  |  |  |  |  | 20 | .... | .... | 1213 | 1238 | 1265 | 1296 |
|  |  |  |  |  | 22 | .... | .... | 1221 | 1248 | 1278 | 1312 |
|  |  |  |  |  | 24 | .... | .... | 1229 | 1259 | 1292 | 1328 |
|  |  |  |  |  | 26 | .... | 1210 | 1237 | 1269 | 1305 | 1345 |
|  |  |  |  |  | 28 | .... | 1216 | 1245 | 1279 | 1318 | 1361 |
|  |  |  |  |  | 30 | .... | 1222 | 1253 | 1290 | 1331 | 1377 |
|  |  | 7/0 | 1½ | 1.32 | 16 | .... | .... |  | 1362 | 1384 | 1409 |
|  |  |  |  |  | 18 | .... | .... |  | 1372 | 1397 | 1425 |
|  |  |  |  |  | 20 |  |  | 1358 | 1383 | 1410 | 1441 |
|  |  |  |  |  | 22 |  |  | 1366 | 1393 | 1423 | 1457 |
|  |  |  |  |  | 24 | .... | .... | 1374 | 1403 | 1436 | 1473 |
|  |  |  |  |  | 26 | .... | .... | 1382 | 1414 | 1450 | 1490 |
|  |  |  |  |  | 28 | .... | 1361 | 1390 | 1424 | 1463 | 1506 |
|  |  |  |  |  | 30 | .... | 1366 | 1398 | 1435 | 1476 | 1522 |
| 43 | 39 | 7/0 | 1⅞ | 1 | 16 | .... | .... | .... | 1278 | 1300 | 1324 |
|  |  |  |  |  | 18 |  |  | .... | 1288 | 1313 | 1340 |
|  |  |  |  |  | 20 |  | .... | 1274 | 1298 | 1326 | 1357 |
|  |  |  |  |  | 22 | .... | .... | 1282 | 1309 | 1339 | 1373 |
|  |  |  |  |  | 24 | .... | .... | 1290 | 1319 | 1352 | 1389 |
|  |  |  |  |  | 26 | .... |  | 1298 | 1329 | 1365 | 1405 |
|  |  |  |  |  | 28 |  | 1276 | 1306 | 1340 | 1378 | 1421 |
|  |  |  |  |  | 30 | .... | 1282 | 1314 | 1350 | 1391 | 1438 |
|  |  | 7/0 | 1½ | 1.29 | 16 | .... | .... | .... | .... | 1438 | 1463 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1451 | 1479 |
|  |  |  |  |  | 20 | .... | .... | .... | 1437 | 1464 | 1495 |
|  |  |  |  |  | 22 | .... | .... | .... | 1447 | 1477 | 1511 |
|  |  |  |  |  | 24 | .... | .... | .... | 1457 | 1490 | 1527 |
|  |  |  |  |  | 26 | .... |  | 1436 | 1468 | 1504 | 1543 |
|  |  |  |  |  | 28 | .... | .... | 1444 | 1478 | 1517 | 1560 |
|  |  |  |  |  | 30 | .... | .... | 1452 | 1489 | 1530 | 1576 |
| 44 | 40 | 7/0 | 1⅞ | 1 | 16 | .... | .... | .... | 1340 | 1362 | 1386 |
|  |  |  |  |  | 18 | .... | .... | .... | 1350 | 1375 | 1402 |
|  |  |  |  |  | 20 | .... | .... | .... | 1360 | 1388 | 1419 |
|  |  |  |  |  | 22 | .... | .... | 1344 | 1371 | 1401 | 1435 |
|  |  |  |  |  | 24 |  | .... | 1352 | 1381 | 1414 | 1451 |
|  |  |  |  |  | 26 | .... | .... | 1360 | 1391 | 1427 | 1467 |
|  |  |  |  |  | 28 |  | 1338 | 1368 | 1402 | 1440 | 1483 |
|  |  |  |  |  | 30 | .... | 1344 | 1376 | 1412 | 1453 | 1499 |
|  |  | 7/0 | 1½ | 1.25 | 16 | .... | .... | .... | .... | 1487 | 1511 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1500 | 1528 |
|  |  |  |  |  | 20 | .... | .... | .... | 1486 | 1513 | 1544 |
|  |  |  |  |  | 22 | .... | .... | .... | 1496 | 1526 | 1560 |
|  |  |  |  |  | 24 | .... | .... | .... | 1506 | 1539 | 1576 |
|  |  |  |  |  | 26 | .... | .... | .... | 1517 | 1553 | 1593 |
|  |  |  |  |  | 28 | .... | .... | 1493 | 1527 | 1566 | 1609 |
|  |  |  |  |  | 30 | .... | .... | 1501 | 1538 | 1579 | 1625 |



# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

*1:2:4 mixture*
$n = 15$
$f_c = 500$

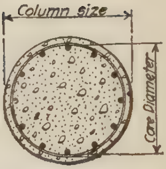
| Size of column (inches) | Diameter of core (inches) | Spirals: Size No. (A. S. & W. Co.) | Spirals: Pitch (inches | Spirals: Per cent of core | Number of rods | Size of vertical round rods: ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 12 | 9 | 1⅛ | 0.5 | 8 | 88 | 97 | | | | |
| | | | | | 10 | 93 | 104 | | | | |
| 16 | 13 | 8 | 1¼ | 0.5 | 8 | 99 | 108 | 119 | | | |
| | | | | | 10 | 104 | 115 | | | | |
| 17 | 14 | 7 | 1⅜ | 0.5 | 8 | 112 | 121 | 131 | | | |
| | | | | | 10 | 117 | 128 | 141 | | | |
| | | | | | 12 | 122 | 135 | | | | |
| | | 0 | 1⅜ | 1.5 | 8 | 147 | 159 | 173 | | | |
| | | | | | 10 | 154 | 168 | 186 | | | |
| | | | | | 12 | 161 | 178 | | | | |
| 18 | 15 | 6 | 1½ | 0.5 | 8 | 125 | 134 | 145 | 157 | | |
| | | | | | 10 | 130 | 142 | 155 | | | |
| | | | | | 12 | 136 | 149 | | | | |
| | | 2/0 | 1½ | 1.5 | 8 | .... | 177 | 191 | 207 | | |
| | | | | | 10 | 172 | 186 | 204 | | | |
| | | | | | 12 | 178 | 196 | | | | |
| 19 | 16 | 6 | 1⅜ | 0.5 | 8 | 140 | 149 | 159 | 172 | 185 | |
| | | | | | 10 | 145 | 156 | 169 | 185 | | |
| | | | | | 12 | 150 | 164 | 179 | | | |
| | | | | | 14 | 155 | 171 | | | | |
| | | 3/0 | 1⅝ | 1.5 | 8 | .... | 196 | 210 | 226 | 244 | |
| | | | | | 10 | 191 | 205 | 223 | 243 | | |
| | | | | | 12 | 197 | 215 | 236 | | | |
| | | | | | 14 | 204 | 225 | | | | |
| 20 | 17 | 5 | 1½ | 0.5 | 8 | 155 | 164 | 175 | 187 | 201 | |
| | | | | | 10 | 160 | 171 | 185 | 200 | | |
| | | | | | 12 | 165 | 179 | 195 | | | |
| | | | | | 14 | 170 | 186 | 205 | | | |
| | | 3/0 | 1⅝ | 1.5 | 8 | .... | 216 | 230 | 246 | 264 | |
| | | | | | 10 | .... | 226 | 243 | 263 | | |
| | | | | | 12 | 218 | 235 | 256 | | | |
| | | | | | 14 | 224 | 245 | 269 | | | |
| 21 | 18 | 4 | 1¾ | 0.5 | 8 | 172 | 180 | 191 | 203 | 217 | 233 |
| | | | | | 10 | 177 | 188 | 201 | 216 | 234 | |
| | | | | | 12 | 182 | 195 | 211 | 230 | | |
| | | | | | 14 | 187 | 203 | 221 | | | |
| | | 3/0 | 1½ | 1.5 | 8 | .... | .... | 251 | 268 | 286 | 306 |
| | | | | | 10 | .... | 247 | 265 | 285 | 307 | |
| | | | | | 12 | .... | 257 | 278 | 302 | | |
| | | | | | 14 | 246 | 266 | 291 | | | |

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

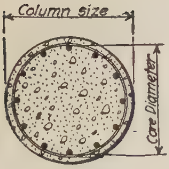
$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

*1:2:4 mixture*
$n = 15$
$f_c = 500$



| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 22 | 19 | 4 | 1⅝ | 0.5 | 8 | 189 | 198 | 208 | 221 | 234 | 250 |
| | | | | | 10 | 194 | 205 | 218 | 234 | 251 | |
| | | | | | 12 | 199 | 213 | 228 | 247 | | |
| | | | | | 14 | 204 | 220 | 238 | 260 | | |
| | | | | | 16 | 209 | 227 | 248 | | | |
| | | 4/0 | 1⅝ | 1.5 | 8 | .... | .... | 274 | 290 | 308 | 329 |
| | | | | | 10 | .... | 270 | 287 | 307 | 330 | |
| | | | | | 12 | .... | 280 | 301 | 325 | | |
| | | | | | 14 | 268 | 289 | 314 | 342 | | |
| | | | | | 16 | 275 | 299 | 327 | | | |
| 23 | 20 | 3 | 1⅞ | 0.5 | 8 | 207 | 216 | 226 | 239 | 253 | 268 |
| | | | | | 10 | 212 | 223 | 236 | 252 | 269 | 289 |
| | | | | | 12 | 217 | 231 | 246 | 265 | 277 | |
| | | | | | 14 | 222 | 238 | 257 | 278 | | |
| | | | | | 16 | 227 | 245 | 267 | 291 | | |
| | | 5/0 | 1⅞ | 1.5 | 8 | .... | .... | 298 | 314 | 332 | 353 |
| | | | | | 10 | .... | .... | 311 | 331 | 354 | 379 |
| | | | | | 12 | .... | 303 | 324 | 349 | 376 | |
| | | | | | 14 | .... | 313 | 337 | 366 | | |
| | | | | | 16 | 299 | 323 | 351 | 383 | | |
| 24 | 21 | 3 | 1¾ | 0.5 | 10 | 231 | 242 | 256 | 271 | 288 | 308 |
| | | | | | 12 | 236 | 250 | 266 | 284 | 305 | |
| | | | | | 14 | 241 | 257 | 276 | 297 | | |
| | | | | | 16 | 246 | 264 | 286 | 310 | | |
| | | 5/0 | 1¾ | 1.5 | 10 | .... | .... | 336 | 357 | 379 | 405 |
| | | | | | 12 | .... | 329 | 350 | 374 | 401 | |
| | | | | | 14 | .... | 338 | 363 | 391 | | |
| | | | | | 16 | .... | 348 | 376 | 408 | | |
| 25 | 22 | 2 | 1⅞ | 0.5 | 10 | 251 | 262 | 276 | 291 | 308 | 328 |
| | | | | | 12 | 256 | 270 | 286 | 304 | 325 | 348 |
| | | | | | 14 | 261 | 277 | 296 | 317 | 341 | |
| | | | | | 16 | 267 | 284 | 306 | 330 | | |
| | | | | | 18 | 272 | 292 | 316 | 343 | | |
| | | 6/0 | 2 | 1.5 | 10 | .... | .... | 363 | 383 | 406 | 431 |
| | | | | | 12 | .... | .... | 376 | 400 | 427 | 458 |
| | | | | | 14 | .... | 365 | 369 | 417 | 449 | |
| | | | | | 16 | .... | 374 | 402 | 435 | | |
| | | | | | 18 | .... | 384 | 416 | 452 | | |
| 26 | 23 | 2 | 1⅞ | 0.5 | 10 | 272 | 283 | 297 | 312 | 329 | 349 |
| | | | | | 12 | 277 | 291 | 307 | 325 | 346 | 369 |
| | | | | | 14 | 283 | 298 | 317 | 338 | 362 | |
| | | | | | 16 | 288 | 305 | 327 | 351 | 379 | |
| | | | | | 18 | 293 | 313 | 337 | 364 | | |
| | | 6/0 | 1⅞ | 1.5 | 10 | .... | .... | .... | 411 | 433 | 459 |
| | | | | | 12 | .... | .... | 404 | 428 | 455 | 486 |
| | | | | | 14 | .... | .... | 417 | 445 | 477 | |
| | | | | | 16 | .... | 402 | 430 | 462 | 499 | |
| | | | | | 18 | .... | 411 | 443 | 479 | | |



# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

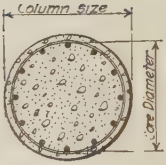
$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$Max.\left(\frac{length}{diameter}\right)=12$$

*1:2:4 mixture*
$n=15$
$f_c=500$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 27 | 24 | 1 | 2 | 0.5 | 10 | 294 | 305 | 318 | 334 | 351 | 370 |
| | | | | | 12 | 299 | 313 | 329 | 347 | 368 | 391 |
| | | | | | 14 | 304 | 320 | 339 | 360 | 384 | 411 |
| | | | | | 16 | 310 | 327 | 349 | 373 | 401 | |
| | | | | | 18 | 315 | 335 | 359 | 386 | 417 | |
| | | 7/0 | 2 | 1.5 | 10 | .... | .... | .... | 439 | 462 | 487 |
| | | | | | 12 | .... | .... | 432 | 457 | 484 | 514 |
| | | | | | 14 | .... | .... | 446 | 474 | 506 | 541 |
| | | | | | 16 | .... | 431 | 459 | 491 | 527 | |
| | | | | | 18 | .... | 440 | 472 | 508 | 549 | |
| 28 | 25 | 1 | 2 | 0.5 | 10 | 317 | 328 | 341 | 357 | 374 | 393 |
| | | | | | 12 | 322 | 335 | 351 | 370 | 391 | 414 |
| | | | | | 14 | 327 | 343 | 361 | 383 | 407 | 434 |
| | | | | | 16 | 332 | 350 | 371 | 396 | 424 | 455 |
| | | | | | 18 | 337 | 358 | 381 | 409 | 440 | |
| | | | | | 20 | 343 | 365 | 391 | 422 | | |
| | | 7/0 | 2 | 1.5 | 10 | .... | .... | .... | 469 | 492 | 518 |
| | | | | | 12 | .... | .... | .... | 487 | 514 | 545 |
| | | | | | 14 | .... | .... | 476 | 504 | 536 | 571 |
| | | | | | 16 | .... | .... | 489 | 521 | 558 | 598 |
| | | | | | 18 | .... | 470 | 502 | 538 | 579 | |
| | | | | | 20 | .... | 480 | 515 | 555 | | |
| 29 | 26 | 0 | 2¼ | 0.5 | 12 | 346 | 359 | 375 | 393 | 414 | 438 |
| | | | | | 14 | 351 | 366 | 385 | 407 | 431 | 458 |
| | | | | | 16 | 356 | 374 | 395 | 420 | 447 | 478 |
| | | | | | 18 | 361 | 381 | 405 | 433 | 464 | |
| | | | | | 20 | 366 | 389 | 415 | 446 | 481 | |
| | | 7/0 | 1⅞ | 1.5 | 12 | .... | .... | .... | 518 | 545 | 576 |
| | | | | | 14 | .... | .... | 507 | 536 | 567 | 602 |
| | | | | | 16 | .... | .... | 520 | 552 | 589 | 630 |
| | | | | | 18 | .... | 502 | 533 | 570 | 610 | |
| | | | | | 20 | .... | 512 | 546 | 588 | 632 | |
| 30 | 27 | 0 | 2⅛ | 0.5 | 12 | 371 | 384 | 400 | 418 | 439 | 462 |
| | | | | | 14 | 376 | 391 | 410 | 431 | 456 | 483 |
| | | | | | 16 | 381 | 399 | 420 | 445 | 472 | 503 |
| | | | | | 18 | 386 | 406 | 430 | 457 | 489 | 524 |
| | | | | | 20 | 391 | 413 | 440 | 471 | 505 | |
| | | | | | 22 | 396 | 421 | 450 | 484 | 522 | |
| | | 7/0 | 1⅞ | 1.5 | 12 | .... | .... | .... | 550 | 578 | 608 |
| | | | | | 14 | .... | .... | .... | 568 | 600 | 635 |
| | | | | | 16 | .... | .... | 552 | 585 | 622 | 662 |
| | | | | | 18 | .... | .... | 566 | 602 | 643 | 689 |
| | | | | | 20 | .... | 544 | 579 | 620 | 664 | |
| | | | | | 22 | .... | 554 | 592 | 636 | 686 | |

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

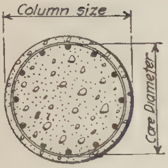


$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

*1:2:4 mixture*
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 31 | 28 | 2/0 | 2⅜ | 0.5 | 12 | 396 | 410 | 425 | 444 | 465 | 488 |
| | | | | | 14 | 401 | 417 | 435 | 457 | 481 | 508 |
| | | | | | 16 | 407 | 424 | 445 | 470 | 498 | 529 |
| | | | | | 18 | 312 | 432 | 455 | 483 | 514 | 549 |
| | | | | | 20 | 417 | 439 | 466 | 496 | 531 | 569 |
| | | | | | 22 | 422 | 447 | 476 | 509 | 548 | |
| | | 7/0 | 1¾ | 1.5 | 12 | .... | .... | .... | 584 | 612 | 642 |
| | | | | | 14 | .... | .... | .... | 602 | 633 | 669 |
| | | | | | 16 | .... | .... | 586 | 619 | 655 | 696 |
| | | | | | 18 | .... | .... | 600 | 646 | 677 | 722 |
| | | | | | 20 | .... | .... | 613 | 653 | 698 | 749 |
| | | | | | 22 | .... | 588 | 626 | 670 | 720 | |
| 32 | 29 | 2/0 | 2⅜ | 0.5 | 12 | 423 | 436 | 452 | 471 | 491 | 514 |
| | | | | | 14 | 428 | 444 | 462 | 484 | 508 | 535 |
| | | | | | 16 | 433 | 451 | 472 | 497 | 524 | 556 |
| | | | | | 18 | 438 | 458 | 482 | 509 | 541 | 576 |
| | | | | | 20 | 443 | 466 | 492 | 523 | 557 | 596 |
| | | | | | 22 | 448 | 473 | 502 | 536 | 574 | |
| | | 7/0 | 1⅝ | 1.5 | 12 | .... | .... | .... | .... | 646 | 677 |
| | | | | | 14 | .... | .... | .... | 637 | 668 | 704 |
| | | | | | 16 | .... | .... | .... | 654 | 690 | 731 |
| | | | | | 18 | .... | .... | 635 | 670 | 712 | 758 |
| | | | | | 20 | .... | .... | 648 | 688 | 734 | 784 |
| | | | | | 22 | .... | .... | 661 | 705 | 755 | |
| 33 | 30 | 2/0 | 2¼ | 0.5 | 12 | 450 | 464 | 479 | 498 | 519 | 542 |
| | | | | | 14 | 456 | 471 | 490 | 511 | 537 | 563 |
| | | | | | 16 | 461 | 479 | 500 | 524 | 552 | 583 |
| | | | | | 18 | 466 | 486 | 510 | 537 | 568 | 603 |
| | | | | | 20 | 471 | 493 | 520 | 550 | 585 | 624 |
| | | | | | 22 | 476 | 500 | 530 | 563 | 602 | 644 |
| | | | | | 24 | 481 | 508 | 540 | 576 | 618 | |
| | | 7/0 | 1⅝ | 1.5 | 12 | .... | .... | .... | .... | 672 | 713 |
| | | | | | 14 | .... | .... | .... | 672 | 704 | 740 |
| | | | | | 16 | .... | .... | .... | 690 | 726 | 767 |
| | | | | | 18 | .... | .... | 670 | 707 | 748 | 794 |
| | | | | | 20 | .... | .... | 684 | 724 | 770 | 821 |
| | | | | | 22 | .... | .... | 697 | 741 | 791 | 847 |
| | | | | | 24 | .... | 668 | 710 | 758 | 813 | |
| 34 | 31 | 3/0 | 2⅝ | 0.5 | 14 | 484 | 500 | 518 | 540 | 564 | 591 |
| | | | | | 16 | 489 | 507 | 528 | 552 | 581 | 611 |
| | | | | | 18 | 494 | 514 | 538 | 566 | 597 | 632 |
| | | | | | 20 | 499 | 522 | 548 | 579 | 613 | 652 |
| | | | | | 22 | 504 | 529 | 558 | 592 | 630 | 672 |
| | | | | | 24 | 510 | 536 | 568 | 605 | 646 | 693 |
| | | 7/0 | 1⅝ | 1.5 | 14 | .... | .... | .... | 710 | 742 | 778 |
| | | | | | 16 | .... | .... | .... | 727 | 764 | 805 |
| | | | | | 18 | .... | .... | 708 | 744 | 785 | 832 |
| | | | | | 20 | .... | .... | 722 | 762 | 807 | 858 |
| | | | | | 22 | .... | .... | 734 | 779 | 829 | 885 |
| | | | | | 24 | .... | .... | 748 | 796 | 851 | 912 |



# ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## CHICAGO BUILDING CODE REQUIREMENTS

$$P = Af_c(1+2.5np')[1+(n-1)p]$$

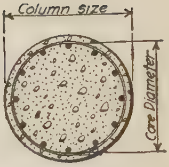
$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

1:2:4 mixture
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 35 | 32 | 3/0 | 2½ | 0.5 | 14 | 513 | 529 | 547 | 569 | 593 | 620 |
|  |  |  |  |  | 16 | 518 | 536 | 557 | 582 | 610 | 641 |
|  |  |  |  |  | 18 | 524 | 544 | 567 | 595 | 626 | 661 |
|  |  |  |  |  | 20 | 529 | 551 | 577 | 608 | 642 | 681 |
|  |  |  |  |  | 22 | 534 | 558 | 587 | 621 | 659 | 702 |
|  |  |  |  |  | 24 | 539 | 566 | 597 | 634 | 676 | 722 |
|  |  | 7/0 | 1½ | 1.5 | 14 | . | . | .... | .... | 780 | 816 |
|  |  |  |  |  | 16 |  | ... | ... | 766 | 802 | 843 |
|  |  |  |  |  | 18 |  | . | .... | 782 | 824 | 870 |
|  |  |  |  |  | 20 | . | ... | .... | 800 | 846 | 896 |
|  |  |  |  |  | 22 | . | . . | 773 | 818 | 867 | 924 |
|  |  |  |  |  | 24 | ... | ... | 786 | 834 | 889 | 950 |
| 36 | 33 | 3/0 | 2½ | 0.5 | 14 | 544 | 559 | 578 | 599 | 623 | 650 |
|  |  |  |  |  | 16 | 549 | 566 | 588 | 612 | 640 | 671 |
|  |  |  |  |  | 18 | 554 | 574 | 598 | 625 | 656 | 691 |
|  |  |  |  |  | 20 | 559 | 581 | 608 | 638 | 673 | 712 |
|  |  |  |  |  | 22 | 564 | 589 | 618 | 651 | 690 | 732 |
|  |  |  |  |  | 24 | 569 | 596 | 628 | 664 | 706 | 752 |
|  |  |  |  |  | 26 | 574 | 603 | 638 | 677 | 723 | 772 |
|  |  | 7/0 | 1½ | 1.5 | 14 | . . | .... | ... | .. | 820 | 856 |
|  |  |  |  |  | 16 | . . | . | . | .. | 842 | 883 |
|  |  |  |  |  | 18 | .. | .. | .... | 823 | 864 | 910 |
|  |  |  |  |  | 20 | .. |  | ... | 840 | 886 | 936 |
|  |  |  |  |  | 22 | . | ... | 813 | 857 | 907 | 963 |
|  |  |  |  |  | 24 | . | ... | 826 | 874 | 929 | 990 |
|  |  |  |  |  | 26 | . . | ... | 839 | 892 | 951 | 1017 |
| 37 | 34 | 3/0 | 2⅜ | 0.5 | 14 | .... | 591 | 609 | 630 | 655 | 682 |
|  |  |  |  |  | 16 | 580 | 598 | 619 | 644 | 671 | 702 |
|  |  |  |  |  | 18 | 585 | 605 | 629 | 657 | 688 | 723 |
|  |  |  |  |  | 20 | 590 | 613 | 639 | 669 | 704 | 743 |
|  |  |  |  |  | 22 | 595 | 620 | 649 | 683 | 721 | 763 |
|  |  |  |  |  | 24 | 600 | 627 | 659 | 696 | 737 | 784 |
|  |  |  |  |  | 26 | 606 | 635 | 669 | 709 | 754 | 804 |
|  |  | 7/0 | 1½ | 1.48 | 14 | . . |  |  | .. | 857 | 893 |
|  |  |  |  |  | 16 | . . |  |  | .. | 879 | 920 |
|  |  |  |  |  | 18 | .... |  |  | 860 | 901 | 946 |
|  |  |  |  |  | 20 | ... | . | . | 876 | 922 | 973 |
|  |  |  |  |  | 22 | ... |  | ... | 894 | 944 | 1000 |
|  |  |  |  |  | 24 | ... | . | 863 | 911 | 966 | 1027 |
|  |  |  |  |  | 26 | ... | . | 876 | 928 | 988 | 1053 |
| 38 | 35 | 3/0 | 2⅜ | 0.5 | 14 | . | 623 | 641 | 663 | 687 | 714 |
|  |  |  |  |  | 16 | 612 | 630 | 651 | 676 | 703 | 734 |
|  |  |  |  |  | 18 | 617 | 638 | 661 | 689 | 720 | 755 |
|  |  |  |  |  | 20 | 622 | 645 | 671 | 702 | 737 | 775 |
|  |  |  |  |  | 22 | 628 | 652 | 681 | 715 | 753 | 795 |
|  |  |  |  |  | 24 | 633 | 660 | 691 | 728 | 769 | 816 |
|  |  |  |  |  | 26 | 638 | 667 | 701 | 741 | 786 | 836 |
|  |  | 7/0 | 1½ | 1.43 | 14 |  |  | ... | .... | 890 | 925 |
|  |  |  |  |  | 16 |  |  | ... | ... | 911 | 951 |
|  |  |  |  |  | 18 |  |  | ... | 892 | 932 | 977 |
|  |  |  |  |  | 20 |  |  | .. | 909 | 954 | 1003 |
|  |  |  |  |  | 22 | . |  | . | 926 | 975 | 1031 |
|  |  |  |  |  | 24 | .. |  | 895 | 943 | 996 | 1057 |
|  |  |  |  |  | 26 | .... | .. | 908 | 959 | 1018 | 1082 |

TABLE 40

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

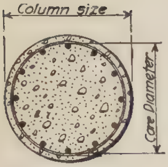


$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

*1:2:4 mixture*
$n = 15$
$f_c = 500$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 39 | 36 | 4/0 | 2⅝ | 0.5 | 16 | .... | 663 | 684 | 709 | 735 | 768 |
| | | | | | 18 | 651 | 671 | 694 | 722 | 753 | 788 |
| | | | | | 20 | 656 | 678 | 704 | 735 | 769 | 808 |
| | | | | | 22 | 661 | 685 | 714 | 748 | 786 | 829 |
| | | | | | 24 | 666 | 693 | 724 | 761 | 803 | 849 |
| | | | | | 26 | 671 | 700 | 734 | 774 | 819 | 870 |
| | | | | | 28 | 676 | 707 | 744 | 787 | 836 | 890 |
| | | 7/0 | 1½ | 1.40 | 16 | .... | .... | .... | .... | 943 | 985 |
| | | | | | 18 | .... | .... | .... | .... | 966 | 1012 |
| | | | | | 20 | .... | .... | .... | 943 | 987 | 1037 |
| | | | | | 22 | .... | .... | .... | 959 | 1008 | 1063 |
| | | | | | 24 | .... | .... | 930 | 976 | 1030 | 1089 |
| | | | | | 26 | .... | .... | 942 | 993 | 1051 | 1116 |
| | | | | | 28 | .... | .... | 955 | 1010 | 1072 | 1142 |
| 40 | 37 | 4/0 | 2⅝ | 0.5 | 16 | .... | 697 | 718 | 743 | 771 | 802 |
| | | | | | 18 | 685 | 705 | 728 | 756 | 787 | 822 |
| | | | | | 20 | 690 | 712 | 738 | 769 | 803 | 842 |
| | | | | | 22 | 695 | 719 | 748 | 782 | 820 | 863 |
| | | | | | 24 | 700 | 727 | 758 | 795 | 837 | 884 |
| | | | | | 26 | 705 | 734 | 768 | 808 | 854 | 905 |
| | | | | | 28 | 710 | 741 | 778 | 821 | 869 | 925 |
| | | 7/0 | 1½ | 1.36 | 16 | .... | .... | .... | .... | 980 | 1019 |
| | | | | | 18 | .... | .... | .... | .... | 1001 | 1045 |
| | | | | | 20 | .... | .... | .... | 978 | 1022 | 1071 |
| | | | | | 22 | .... | .... | .... | 994 | 1043 | 1097 |
| | | | | | 24 | .... | .... | .... | 1011 | 1064 | 1123 |
| | | | | | 26 | .... | .... | 976 | 1027 | 1085 | 1148 |
| | | | | | 28 | .... | .... | 989 | 1044 | 1105 | 1174 |
| 41 | 38 | 4/0 | 2½ | 0.5 | 16 | .... | 732 | 753 | 778 | 806 | 836 |
| | | | | | 18 | .... | 740 | 763 | 791 | 822 | 857 |
| | | | | | 20 | 725 | 747 | 773 | 804 | 839 | 877 |
| | | | | | 22 | 730 | 754 | 783 | 817 | 856 | 898 |
| | | | | | 24 | 735 | 762 | 793 | 830 | 873 | 919 |
| | | | | | 26 | 740 | 769 | 803 | 843 | 889 | 939 |
| | | | | | 28 | 745 | 776 | 813 | 856 | 906 | 960 |
| | | | | | 30 | 750 | 784 | 823 | 870 | 922 | 980 |
| | | 7/0 | 1½ | 1.32 | 16 | .... | .... | .... | .... | 1015 | 1054 |
| | | | | | 18 | .... | .... | .... | .... | 1035 | 1079 |
| | | | | | 20 | .... | .... | .... | 1012 | 1057 | 1105 |
| | | | | | 22 | .... | .... | .... | 1029 | 1077 | 1131 |
| | | | | | 24 | .... | .... | .... | 1045 | 1098 | 1157 |
| | | | | | 26 | .... | .... | 1012 | 1062 | 1118 | 1183 |
| | | | | | 28 | .... | .... | 1024 | 1078 | 1140 | 1209 |
| | | | | | 30 | .... | .... | 1037 | 1095 | 1161 | 1234 |



# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

$$P = Af_c(1+2.5np')[1+(n-1)p]$$

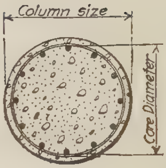
$$\text{Max.}\left(\frac{length}{diameter}\right)=12$$

1:2:4 mixture
$n=15$
$f_c=500$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 42 | 39 | 4/0 | 2½ | 0.5 | 16 | .... | 768 | 789 | 813 | 841 | 873 |
| | | | | | 18 | .... | 776 | 799 | 827 | 858 | 894 |
| | | | | | 20 | 761 | 783 | 809 | 840 | 875 | 914 |
| | | | | | 22 | 766 | 790 | 819 | 853 | 892 | 934 |
| | | | | | 24 | 771 | 798 | 829 | 866 | 908 | 954 |
| | | | | | 26 | 776 | 805 | 839 | 879 | 924 | 975 |
| | | | | | 28 | 781 | 812 | 849 | 892 | 941 | 996 |
| | | | | | 30 | 786 | 820 | 859 | 905 | 957 | 1016 |
| | | 7/0 | 1½ | 1.29 | 16 | .... | .... | .... | .... | 1052 | 1091 |
| | | | | | 18 | .... | .... | .... | .... | 1073 | 1117 |
| | | | | | 20 | .... | .... | .... | 1049 | 1093 | 1142 |
| | | | | | 22 | .... | .... | .... | 1065 | 1114 | 1167 |
| | | | | | 24 | .... | .... | .... | 1082 | 1134 | 1193 |
| | | | | | 26 | .... | .... | 1048 | 1098 | 1155 | 1218 |
| | | | | | 28 | .... | .... | 1061 | 1115 | 1175 | 1244 |
| | | | | | 30 | .... | .... | 1074 | 1131 | 1196 | 1269 |
| 43 | 40 | 4/0 | 2⅜ | 0.5 | 16 | .... | 805 | 826 | 851 | 879 | 909 |
| | | | | | 18 | .... | 813 | 836 | 864 | 895 | 930 |
| | | | | | 20 | .... | 820 | 846 | 877 | 911 | 950 |
| | | | | | 22 | 803 | 827 | 856 | 890 | 928 | 970 |
| | | | | | 24 | 808 | 835 | 866 | 903 | 944 | 991 |
| | | | | | 26 | 813 | 842 | 876 | 916 | 961 | 1011 |
| | | | | | 28 | 818 | 849 | 886 | 929 | 978 | 1032 |
| | | | | | 30 | 823 | 857 | 896 | 942 | 995 | 1052 |
| | | 7/0 | 1½ | 1.25 | 16 | .... | .... | .... | .... | 1087 | 1124 |
| | | | | | 18 | .... | .... | .... | .... | 1107 | 1150 |
| | | | | | 20 | .... | .... | .... | 1085 | 1127 | 1175 |
| | | | | | 22 | .... | .... | .... | 1100 | 1147 | 1200 |
| | | | | | 24 | .... | .... | .... | 1116 | 1168 | 1225 |
| | | | | | 26 | .... | .... | .... | 1133 | 1188 | 1250 |
| | | | | | 28 | .... | .... | 1096 | 1148 | 1208 | 1275 |
| | | | | | 30 | .... | .... | 1108 | 1164 | 1228 | 1300 |

**COLUMNS**

## ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS CHICAGO BUILDING CODE REQUIREMENTS

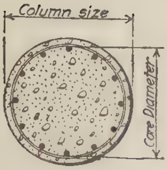


*1:1½:3 mixture*
$n = 12$
$f_c = 600$

$$P = Af_c(1 + 2.5np')[1 + (n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 15 | 12 | 9 | 1⅛ | 0.5 | 8 | 97 | 105 | | | | |
| | | | | | 10 | 101 | 112 | | | | |
| 16 | 13 | 8 | 1¼ | 0.5 | 8 | 110 | 118 | | | | |
| | | | | | 10 | 115 | 125 | | | | |
| 17 | 14 | 7 | 1⅜ | 0.5 | 8 | 125 | 133 | 143 | | | |
| | | | | | 10 | 130 | 140 | 152 | | | |
| | | | | | 12 | 134 | 146 | | | | |
| | | 0 | 1⅜ | 1.5 | 8 | 157 | 168 | 180 | | | |
| | | | | | 10 | 163 | 176 | 191 | | | |
| | | | | | 12 | 169 | 185 | | | | |
| 18 | 15 | 6 | 1½ | 0.5 | 8 | 141 | 149 | 158 | 170 | | |
| | | | | | 10 | 145 | 155 | 168 | | | |
| | | | | | 12 | 150 | 162 | | | | |
| | | 2/0 | 1½ | 1.5 | 8 | .... | 188 | 200 | 214 | | |
| | | | | | 10 | 183 | 196 | 211 | | | |
| | | | | | 12 | 189 | 204 | | | | |
| 19 | 16 | 6 | 1⅜ | 0.5 | 8 | 157 | 166 | 175 | 186 | 199 | |
| | | | | | 10 | 162 | 172 | 184 | 198 | | |
| | | | | | 12 | 167 | 179 | 194 | | | |
| | | | | | 14 | 171 | 186 | | | | |
| | | 3/0 | 1⅝ | 1.5 | 8 | .... | 209 | 221 | 235 | 251 | |
| | | | | | 10 | 204 | 217 | 233 | 250 | | |
| | | | | | 12 | 210 | 226 | 244 | | | |
| | | | | | 14 | 216 | 234 | | | | |
| 20 | 17 | 5 | 1½ | 0.5 | 8 | 175 | 183 | 193 | 204 | 217 | |
| | | | | | 10 | 180 | 190 | 202 | 216 | | |
| | | | | | 12 | 185 | 197 | 211 | | | |
| | | | | | 14 | 189 | 204 | 221 | | | |
| | | 3/0 | 1⅝ | 1.5 | 8 | .... | 231 | 244 | 258 | 274 | |
| | | | | | 10 | .... | 240 | 255 | 273 | | |
| | | | | | 12 | 233 | 248 | 267 | | | |
| | | | | | 14 | 239 | 257 | 278 | | | |
| 21 | 18 | 4 | 1¾ | 0.5 | 8 | 194 | 202 | 212 | 224 | 236 | 250 |
| | | | | | 10 | 199 | 209 | 221 | 235 | 251 | |
| | | | | | 12 | 204 | 216 | 230 | 247 | | |
| | | | | | 14 | 208 | 223 | 239 | | | |
| | | 3/0 | 1½ | 1.5 | 8 | .... | .... | 267 | 282 | 298 | 315 |
| | | | | | 10 | .... | 264 | 279 | 297 | 317 | |
| | | | | | 12 | .... | 272 | 290 | 312 | | |
| | | | | | 14 | 263 | 281 | 302 | | | |



## ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## CHICAGO BUILDING CODE REQUIREMENTS

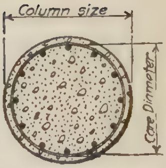
$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

*1:1½:3 mixture*
$n = 12$
$f_c = 600$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | 5/8 | 3/4 | 7/8 | 1 | 1⅛ | 1¼ |
| 22 | 19 | 4 | 1⅝ | 0.5 | 8 | 214 | 222 | 232 | 243 | 256 | 270 |
| | | | | | 10 | 219 | 229 | 241 | 255 | 271 | |
| | | | | | 12 | 224 | 236 | 250 | 267 | | |
| | | | | | 14 | 228 | 243 | 259 | 279 | | |
| | | | | | 16 | 233 | 249 | 269 | | | |
| | | 4/0 | 1⅝ | 1.5 | 8 | .... | .... | 293 | 307 | 323 | 341 |
| | | | | | 10 | .... | 289 | 304 | 322 | 342 | |
| | | | | | 12 | .... | 297 | 316 | 337 | | |
| | | | | | 14 | 288 | 306 | 327 | 352 | | |
| | | | | | 16 | 294 | 314 | 339 | | | |
| 23 | 20 | 3 | 1⅞ | 0.5 | 8 | 227 | 244 | 253 | 265 | 277 | 291 |
| | | | | | 10 | 231 | 250 | 263 | 276 | 292 | 310 |
| | | | | | 12 | 245 | 257 | 271 | 288 | 307 | |
| | | | | | 14 | 249 | 264 | 281 | 300 | | |
| | | | | | 16 | 254 | 270 | 290 | 312 | | |
| | | 5/0 | 1⅞ | 1.5 | 8 | .... | .... | 319 | 333 | 349 | 367 |
| | | | | | 10 | .... | .... | 331 | 349 | 368 | 391 |
| | | | | | 12 | .... | 324 | 342 | 364 | 388 | |
| | | | | | 14 | .... | 333 | 354 | 379 | | |
| | | | | | 16 | 320 | 341 | 365 | 394 | | |
| 24 | 21 | 3 | 1¾ | 0.5 | 10 | 262 | 272 | 285 | 299 | 314 | 332 |
| | | | | | 12 | 267 | 279 | 294 | 311 | 330 | |
| | | | | | 14 | 272 | 286 | 303 | 322 | | |
| | | | | | 16 | 276 | 293 | 313 | 334 | | |
| | | 5/0 | 1¾ | 1.5 | 10 | .... | .... | 359 | 377 | 396 | 419 |
| | | | | | 12 | .... | 352 | 370 | 392 | 416 | |
| | | | | | 14 | .... | 361 | 382 | 407 | | |
| | | | | | 16 | . . | 369 | 393 | 422 | | |
| 25 | 22 | 2 | 1⅞ | 0.5 | 10 | 286 | 296 | 308 | 322 | 338 | 356 |
| | | | | | 12 | 290 | 302 | 317 | 334 | 353 | 374 |
| | | | | | 14 | 295 | 309 | 326 | 346 | 368 | |
| | | | | | 16 | 299 | 316 | 335 | 358 | | |
| | | | | | 18 | 304 | 322 | 344 | 370 | | |
| | | 6/0 | 2 | 1.5 | 10 | ... | .... | 388 | 406 | 426 | 448 |
| | | | | | 12 | .... | .... | 400 | 421 | 445 | 472 |
| | | | | | 14 | ... | 390 | 411 | 436 | 464 | |
| | | | | | 16 | .. | 398 | 423 | 451 | | |
| | | | | | 18 | . | 407 | 434 | 466 | | |
| 26 | 23 | 2 | 1⅞ | 0.5 | 10 | 310 | 320 | 332 | 346 | 362 | 380 |
| | | | | | 12 | 315 | 327 | 342 | 358 | 377 | 398 |
| | | | | | 14 | 319 | 334 | 350 | 370 | 392 | |
| | | | | | 16 | 324 | 340 | 360 | 382 | 408 | |
| | | | | | 18 | 329 | 347 | 369 | 394 | | |
| | | 6/0 | 1⅞ | 1.5 | 10 | ... | .... | .... | 437 | 457 | 479 |
| | | | | | 12 | .. | .... | 431 | 452 | 476 | 502 |
| | | | | | 14 | ... | .... | 442 | 467 | 495 | |
| | | | | | 16 | ... | 429 | 454 | 482 | 514 | |
| | | | | | 18 | .... | 438 | 465 | 497 | | |

## ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## CHICAGO BUILDING CODE REQUIREMENTS

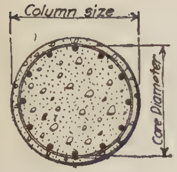


$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

*1:1½:3 mixture*
*$n = 12$*
*$f_c = 600$*

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 27 | 24 | 1 | 2 | 0.5 | 10 | 335 | 346 | 358 | 372 | 388 | 405 |
|  |  |  |  |  | 12 | 340 | 352 | 367 | 384 | 403 | 424 |
|  |  |  |  |  | 14 | 345 | 359 | 376 | 396 | 418 | 443 |
|  |  |  |  |  | 16 | 349 | 366 | 385 | 408 | 433 |  |
|  |  |  |  |  | 18 | 354 | 372 | 394 | 420 | 448 |  |
|  |  | 7/0 | 2 | 1.5 | 10 | .... | .... | .... | 469 | 489 | 511 |
|  |  |  |  |  | 12 | .... | .... | 463 | 484 | 508 | 535 |
|  |  |  |  |  | 14 | .... | .... | 474 | 499 | 527 | 558 |
|  |  |  |  |  | 16 | .... | 461 | 486 | 514 | 546 |  |
|  |  |  |  |  | 18 | .... | 470 | 497 | 529 | 565 |  |
| 28 | 25 | 1 | 2 | 0.5 | 10 | 362 | 372 | 384 | 399 | 414 | 432 |
|  |  |  |  |  | 12 | 367 | 379 | 394 | 410 | 429 | 451 |
|  |  |  |  |  | 14 | 371 | 386 | 403 | 423 | 444 | 469 |
|  |  |  |  |  | 16 | 376 | 392 | 412 | 434 | 459 | 488 |
|  |  |  |  |  | 18 | 380 | 399 | 421 | 446 | 474 |  |
|  |  |  |  |  | 20 | 385 | 406 | 430 | 458 |  |  |
|  |  | 7/0 | 2 | 1.5 | 10 | .... | .... | .... | 502 | 522 | 545 |
|  |  |  |  |  | 12 | .... | .... | .... | 517 | 541 | 568 |
|  |  |  |  |  | 14 | .... | .... | 508 | 532 | 560 | 592 |
|  |  |  |  |  | 16 | .... | .... | 519 | 547 | 579 | 615 |
|  |  |  |  |  | 18 | .... | 503 | 531 | 562 | 598 |  |
|  |  |  |  |  | 20 | .... | 512 | 542 | 577 |  |  |
| 29 | 26 | 0 | 2¼ | 0.5 | 12 | 394 | 407 | 421 | 438 | 457 | 478 |
|  |  |  |  |  | 14 | 399 | 413 | 430 | 450 | 472 | 497 |
|  |  |  |  |  | 16 | 404 | 420 | 439 | 462 | 487 | 516 |
|  |  |  |  |  | 18 | 408 | 427 | 448 | 473 | 502 |  |
|  |  |  |  |  | 20 | 413 | 433 | 458 | 485 | 516 |  |
|  |  | 7/0 | 1⅞ | 1.5 | 12 | .... | .... | .... | 552 | 576 | 603 |
|  |  |  |  |  | 14 | .... | .... | 542 | 567 | 595 | 626 |
|  |  |  |  |  | 16 | .... | .... | 554 | 582 | 614 | 650 |
|  |  |  |  |  | 18 | .... | 538 | 565 | 597 | 633 |  |
|  |  |  |  |  | 20 | .... | 546 | 577 | 612 | 652 |  |
| 30 | 27 | 0 | 2⅛ | 0.5 | 12 | 423 | 435 | 450 | 467 | 486 | 507 |
|  |  |  |  |  | 14 | 428 | 442 | 459 | 479 | 501 | 525 |
|  |  |  |  |  | 16 | 432 | 449 | 468 | 491 | 516 | 544 |
|  |  |  |  |  | 18 | 437 | 455 | 477 | 502 | 531 | 563 |
|  |  |  |  |  | 20 | 442 | 462 | 486 | 514 | 546 |  |
|  |  |  |  |  | 22 | 446 | 469 | 495 | 526 | 561 |  |
|  |  | 7/0 | 1⅞ | 1.5 | 12 | .... | .... | .... | 588 | 612 | 639 |
|  |  |  |  |  | 14 | .... | .... | .... | 603 | 631 | 663 |
|  |  |  |  |  | 16 | .... | .... | 590 | 618 | 650 | 686 |
|  |  |  |  |  | 18 | .... | .... | 602 | 633 | 669 | 710 |
|  |  |  |  |  | 20 | .... | 583 | 613 | 648 | 688 |  |
|  |  |  |  |  | 22 | .... | 591 | 624 | 664 | 707 |  |



# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

$$P=Af_c(1+2.5np')[1+(n-1)p]$$

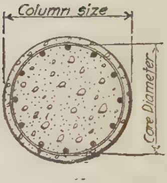
$$Max.\left(\frac{length}{diameter}\right)=12$$

1:1½:3 mixture
$n=12$
$f_c=600$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 31 | 28 | 2/0 | 2⅜ | 0.5 | 12 | 453 | 465 | 480 | 497 | 515 | 545 |
|  |  |  |  |  | 14 | 458 | 472 | 489 | 508 | 530 | 555 |
|  |  |  |  |  | 16 | 462 | 479 | 498 | 520 | 546 | 574 |
|  |  |  |  |  | 18 | 467 | 485 | 507 | 532 | 561 | 593 |
|  |  |  |  |  | 20 | 471 | 492 | 516 | 544 | 576 | 611 |
|  |  |  |  |  | 22 | 476 | 499 | 525 | 556 | 591 |  |
|  |  | 7/0 | 1¾ | 1.5 | 12 | .... | .... | .... | 626 | 650 | 687 |
|  |  |  |  |  | 14 | .... | .... | .... | 641 | 669 | 700 |
|  |  |  |  |  | 16 | .... | .... | 628 | 656 | 688 | 724 |
|  |  |  |  |  | 18 | .... | .... | 639 | 671 | 707 | 747 |
|  |  |  |  |  | 20 | .... | .... | 651 | 686 | 726 | 771 |
|  |  |  |  |  | 22 | .... | 629 | 662 | 701 | 745 |  |
| 32 | 29 | 2/0 | 2⅜ | 0.5 | 12 | 484 | 496 | 510 | 527 | 547 | 568 |
|  |  |  |  |  | 14 | 488 | 503 | 520 | 539 | 562 | 586 |
|  |  |  |  |  | 16 | 493 | 509 | 529 | 551 | 577 | 605 |
|  |  |  |  |  | 18 | 498 | 516 | 538 | 563 | 592 | 624 |
|  |  |  |  |  | 20 | 502 | 523 | 546 | 575 | 606 | 642 |
|  |  |  |  |  | 22 | 507 | 530 | 556 | 587 | 622 |  |
|  |  | 7/0 | 1⅝ | 1.5 | 12 | .... | .... | .... | .... | 689 | 716 |
|  |  |  |  |  | 14 | .... | .... | .... | 680 | 708 | 739 |
|  |  |  |  |  | 16 | .... | .... | .... | 695 | 727 | 763 |
|  |  |  |  |  | 18 | .... | .... | 678 | 710 | 746 | 786 |
|  |  |  |  |  | 20 | .... | .... | 690 | 725 | 765 | 810 |
|  |  |  |  |  | 22 | .... | .... | 701 | 740 | 784 |  |
| 33 | 30 | 2/0 | 2¼ | 0.5 | 12 | 516 | 528 | 542 | 559 | 578 | 599 |
|  |  |  |  |  | 14 | 520 | 535 | 552 | 571 | 593 | 618 |
|  |  |  |  |  | 16 | 525 | 541 | 561 | 583 | 608 | 637 |
|  |  |  |  |  | 18 | 530 | 548 | 570 | 595 | 624 | 656 |
|  |  |  |  |  | 20 | 534 | 555 | 579 | 607 | 639 | 674 |
|  |  |  |  |  | 22 | 539 | 562 | 588 | 619 | 654 | 693 |
|  |  |  |  |  | 24 | 544 | 568 | 597 | 631 | 669 |  |
|  |  | 7/0 | 1⅝ | 1.5 | 12 | .... | .... | .... | .... | 729 | 756 |
|  |  |  |  |  | 14 | .... | .... | .... | 720 | 748 | 779 |
|  |  |  |  |  | 16 | .... | .... | .... | 735 | 767 | 803 |
|  |  |  |  |  | 18 | .... | .... | 719 | 750 | 786 | 826 |
|  |  |  |  |  | 20 | .... | .... | 730 | 765 | 805 | 850 |
|  |  |  |  |  | 22 | .... | .... | 742 | 780 | 824 | 873 |
|  |  |  |  |  | 24 | .... | 716 | 753 | 795 | 843 |  |
| 34 | 31 | 3/0 | 2⅝ | 0.5 | 14 | 553 | 568 | 585 | 605 | 627 | 651 |
|  |  |  |  |  | 16 | 558 | 574 | 594 | 617 | 642 | 670 |
|  |  |  |  |  | 18 | 563 | 581 | 603 | 629 | 657 | 688 |
|  |  |  |  |  | 20 | 567 | 588 | 612 | 641 | 672 | 707 |
|  |  |  |  |  | 22 | 572 | 595 | 622 | 653 | 687 | 726 |
|  |  |  |  |  | 24 | 577 | 602 | 631 | 665 | 702 | 745 |
|  |  | 7/0 | 1⅝ | 1.5 | 14 | .... | .... | .... | 762 | 790 | 821 |
|  |  |  |  |  | 16 | .... | .... | .... | 777 | 809 | 845 |
|  |  |  |  |  | 18 | .... | .... | 761 | 792 | 828 | 868 |
|  |  |  |  |  | 20 | .... | .... | 772 | 807 | 847 | 892 |
|  |  |  |  |  | 22 | .... | .... | 784 | 822 | 866 | 915 |
|  |  |  |  |  | 24 | .... | .... | 795 | 837 | 885 | 939 |

TABLE 41

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

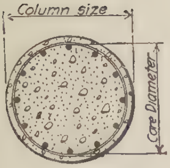


$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$Max.\left(\frac{length}{diameter}\right) = 12$$

*1:1½:3 mixture*
$n = 12$
$f_c = 600$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 35 | 32 | 3/0 | 2½ | 0.5 | 14 | 587 | 602 | 619 | 638 | 661 | 685 |
| | | | | | 16 | 592 | 608 | 628 | 650 | 676 | 704 |
| | | | | | 18 | 597 | 615 | 637 | 662 | 691 | 722 |
| | | | | | 20 | 601 | 622 | 646 | 674 | 706 | 741 |
| | | | | | 22 | 606 | 629 | 655 | 686 | 721 | 760 |
| | | | | | 24 | 611 | 635 | 664 | 698 | 736 | 779 |
| | | 7/0 | 1½ | 1.5 | 14 | .... | .... | .... | .... | 833 | 864 |
| | | | | | 16 | .... | .... | .... | 820 | 852 | 888 |
| | | | | | 18 | .... | .... | .... | 835 | 871 | 911 |
| | | | | | 20 | .... | .... | .... | 850 | 890 | 935 |
| | | | | | 22 | .... | .... | 826 | 865 | 909 | 958 |
| | | | | | 24 | .... | .... | 838 | 880 | 928 | 982 |
| 36 | 33 | 3/0 | 2½ | 0.5 | 14 | 623 | 637 | 654 | 674 | 696 | 721 |
| | | | | | 16 | 627 | 644 | 663 | 685 | 711 | 739 |
| | | | | | 18 | 632 | 650 | 673 | 697 | 726 | 758 |
| | | | | | 20 | 637 | 657 | 682 | 709 | 741 | 777 |
| | | | | | 22 | 641 | 664 | 691 | 721 | 756 | 795 |
| | | | | | 24 | 646 | 670 | 700 | 733 | 771 | 813 |
| | | | | | 26 | 652 | 677 | 709 | 745 | 786 | 832 |
| | | 7/0 | 1½ | 1.5 | 14 | .... | .... | .... | .... | 877 | 909 |
| | | | | | 16 | .... | .... | .... | .... | 896 | 932 |
| | | | | | 18 | .... | .... | .... | 879 | 915 | 956 |
| | | | | | 20 | .... | .... | .... | 894 | 934 | 979 |
| | | | | | 22 | .... | .... | 871 | 909 | 953 | 1002 |
| | | | | | 24 | .... | .... | 882 | 925 | 972 | 1026 |
| | | | | | 26 | .... | .... | 894 | 940 | 991 | 1049 |
| 37 | 34 | 3/0 | 2⅜ | 0.5 | 14 | .... | 673 | 690 | 710 | 732 | 757 |
| | | | | | 16 | 664 | 680 | 699 | 722 | 747 | 775 |
| | | | | | 18 | 668 | 687 | 708 | 734 | 762 | 794 |
| | | | | | 20 | 673 | 693 | 717 | 746 | 777 | 813 |
| | | | | | 22 | 678 | 700 | 727 | 758 | 792 | 831 |
| | | | | | 24 | 682 | 707 | 736 | 770 | 807 | 850 |
| | | | | | 26 | 687 | 714 | 745 | 782 | 822 | 868 |
| | | 7/0 | 1½ | 1.48 | 14 | .... | .... | .... | .... | 919 | 949 |
| | | | | | 16 | .... | .... | .... | .... | 937 | 973 |
| | | | | | 18 | .... | .... | .... | 921 | 956 | 996 |
| | | | | | 20 | .... | .... | .... | 936 | 975 | 1019 |
| | | | | | 22 | .... | .... | .... | 950 | 994 | 1042 |
| | | | | | 24 | .... | .... | 923 | 965 | 1013 | 1065 |
| | | | | | 26 | .... | .... | 935 | 980 | 1031 | 1089 |
| 38 | 35 | 3/0 | 2⅜ | 0.5 | 14 | .... | 711 | 727 | 747 | 769 | 794 |
| | | | | | 16 | 701 | 717 | 737 | 759 | 784 | 813 |
| | | | | | 18 | 706 | 724 | 746 | 771 | 800 | 832 |
| | | | | | 20 | 710 | 731 | 755 | 783 | 815 | 851 |
| | | | | | 22 | 715 | 738 | 764 | 794 | 830 | 869 |
| | | | | | 24 | 720 | 744 | 773 | 806 | 845 | 887 |
| | | | | | 26 | 725 | 751 | 782 | 819 | 860 | 906 |
| | | 7/0 | 1½ | 1.43 | 14 | .... | .... | .... | .... | 956 | 987 |
| | | | | | 16 | .... | .... | .... | .... | 975 | 1010 |
| | | | | | 18 | .... | .... | .... | 958 | 994 | 1033 |
| | | | | | 20 | .... | .... | .... | 973 | 1013 | 1056 |
| | | | | | 22 | .... | .... | .... | 988 | 1031 | 1080 |
| | | | | | 24 | .... | .... | 961 | 1003 | 1050 | 1103 |
| | | | | | 26 | .... | .... | 973 | 1018 | 1069 | 1126 |



# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

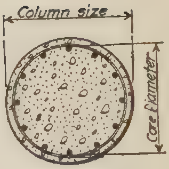
$$P = Af_c(1+2.5np')[1+(n-1)p]$$
$$Max. \left(\frac{length}{diameter}\right) = 12$$

*1:1½:3 mixture*
$n = 12$
$f_c = 600$

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 39 | 36 | 4/0 | 2⅝ | 0.5 | 16 | .... | 756 | 775 | 798 | 823 | 851 |
|  |  |  |  |  | 18 | 744 | 763 | 784 | 810 | 838 | 870 |
|  |  |  |  |  | 20 | 749 | 769 | 794 | 821 | 853 | 889 |
|  |  |  |  |  | 22 | 754 | 776 | 803 | 833 | 869 | 908 |
|  |  |  |  |  | 24 | 758 | 783 | 812 | 845 | 884 | 926 |
|  |  |  |  |  | 26 | 763 | 789 | 821 | 857 | 899 | 945 |
|  |  |  |  |  | 28 | 768 | 796 | 830 | 869 | 914 | 964 |
|  |  | 7/0 | 1½ | 1.40 | 16 | .... | .... | .... | .... | 1016 | 1052 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1035 | 1075 |
|  |  |  |  |  | 20 | .... | .... | .... | 1015 | 1054 | 1098 |
|  |  |  |  |  | 22 | .... | .... | .... | 1030 | 1073 | 1121 |
|  |  |  |  |  | 24 | .... | .... | 1003 | 1044 | 1092 | 1145 |
|  |  |  |  |  | 26 | .... | .... | 1014 | 1059 | 1110 | 1168 |
|  |  |  |  |  | 28 | .... | .... | 1025 | 1074 | 1129 | 1191 |
| 40 | 37 | 4/0 | 2⅝ | 0.5 | 16 | .... | 795 | 815 | 837 | 863 | 891 |
|  |  |  |  |  | 18 | 784 | 802 | 824 | 850 | 878 | 909 |
|  |  |  |  |  | 20 | 788 | 809 | 833 | 861 | 893 | 928 |
|  |  |  |  |  | 22 | 793 | 816 | 842 | 873 | 909 | 947 |
|  |  |  |  |  | 24 | 798 | 822 | 851 | 885 | 924 | 965 |
|  |  |  |  |  | 26 | 803 | 829 | 860 | 897 | 939 | 984 |
|  |  |  |  |  | 28 | 807 | 836 | 869 | 909 | 954 | 1003 |
|  |  | 7/0 | 1½ | 1.36 | 16 | .... | .... | .... | .... | 1056 | 1091 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1074 | 1113 |
|  |  |  |  |  | 20 | .... | .... | .... | 1055 | 1093 | 1136 |
|  |  |  |  |  | 22 | .... | .... | .... | 1070 | 1111 | 1159 |
|  |  |  |  |  | 24 | .... | .... | .... | 1084 | 1130 | 1182 |
|  |  |  |  |  | 26 | .... | .... | 1054 | 1098 | 1148 | 1205 |
|  |  |  |  |  | 28 | .... | .... | 1065 | 1113 | 1167 | 1228 |
| 41 | 38 | 4/0 | 2½ | 0.5 | 16 | .... | 836 | 856 | 879 | 903 | 932 |
|  |  |  |  |  | 18 | .... | 843 | 865 | 890 | 918 | 951 |
|  |  |  |  |  | 20 | 829 | 850 | 874 | 902 | 934 | 970 |
|  |  |  |  |  | 22 | 834 | 856 | 883 | 914 | 949 | 988 |
|  |  |  |  |  | 24 | 839 | 863 | 892 | 926 | 964 | 1007 |
|  |  |  |  |  | 26 | 844 | 870 | 901 | 938 | 979 | 1025 |
|  |  |  |  |  | 28 | 848 | 876 | 910 | 950 | 994 | 1044 |
|  |  |  |  |  | 30 | 852 | 883 | 919 | 962 | 1009 | 1063 |
|  |  | 7/0 | 1½ | 1.32 | 16 | .... | .... | .... | .... | 1096 | 1131 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1115 | 1154 |
|  |  |  |  |  | 20 | .... | .... | .... | 1095 | 1133 | 1176 |
|  |  |  |  |  | 22 | .... | .... | .... | 1109 | 1152 | 1199 |
|  |  |  |  |  | 24 | .... | .... | .... | 1124 | 1170 | 1221 |
|  |  |  |  |  | 26 | .... | .... | 1094 | 1138 | 1188 | 1244 |
|  |  |  |  |  | 28 | .... | .... | 1105 | 1153 | 1207 | 1267 |
|  |  |  |  |  | 30 | .... | .... | 1116 | 1167 | 1225 | 1289 |

TABLE 41

## ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## CHICAGO BUILDING CODE REQUIREMENTS

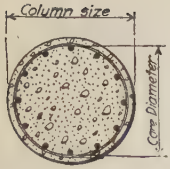


*1:1½:3 mixture*
$n = 12$
$f_c = 600$

$$P = Af_c(1 + 2.5np')[1 + (n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 42 | 39 | 4/0 | 2½ | 0.5 | 16 | .... | 878 | 897 | 920 | 945 | 973 |
| | | | | | 18 | .... | 885 | 906 | 932 | 960 | 992 |
| | | | | | 20 | 871 | 891 | 916 | 944 | 975 | 1010 |
| | | | | | 22 | 876 | 898 | 925 | 956 | 990 | 1029 |
| | | | | | 24 | 880 | 905 | 934 | 967 | 1004 | 1048 |
| | | | | | 26 | 885 | 911 | 943 | 979 | 1019 | 1066 |
| | | | | | 28 | 889 | 918 | 953 | 991 | 1034 | 1084 |
| | | | | | 30 | 894 | 924 | 962 | 1003 | 1050 | 1103 |
| | | 7/0 | 1½ | 1.29 | 16 | .... | .... | .... | .... | 1140 | 1172 |
| | | | | | 18 | .... | .... | .... | .... | 1158 | 1196 |
| | | | | | 20 | .... | .... | .... | 1138 | 1176 | 1219 |
| | | | | | 22 | .... | .... | .... | 1152 | 1194 | 1241 |
| | | | | | 24 | .... | .... | .... | 1167 | 1212 | 1264 |
| | | | | | 26 | .... | .... | 1137 | 1181 | 1230 | 1286 |
| | | | | | 28 | .... | .... | 1148 | 1195 | 1249 | 1309 |
| | | | | | 30 | .... | .... | 1159 | 1210 | 1267 | 1331 |
| 43 | 40 | 4/0 | 2⅜ | 0.5 | 16 | .... | 921 | 940 | 962 | 988 | 1016 |
| | | | | | 18 | .... | 927 | 949 | 974 | 1003 | 1035 |
| | | | | | 20 | .... | 934 | 958 | 986 | 1018 | 1053 |
| | | | | | 22 | 918 | 941 | 968 | 998 | 1033 | 1072 |
| | | | | | 24 | 923 | 947 | 977 | 1010 | 1048 | 1090 |
| | | | | | 26 | 928 | 954 | 986 | 1022 | 1062 | 1109 |
| | | | | | 28 | 932 | 961 | 995 | 1034 | 1077 | 1128 |
| | | | | | 30 | 937 | 968 | 1004 | 1046 | 1092 | 1146 |
| | | 7/0 | 1½ | 1.25 | 16 | ... | .... | .... | .... | 1181 | 1215 |
| | | | | | 18 | .... | .... | .... | .... | 1199 | 1237 |
| | | | | | 20 | .... | .... | .... | 1179 | 1217 | 1259 |
| | | | | | 22 | .... | .... | .... | 1193 | 1235 | 1282 |
| | | | | | 24 | .... | .... | .... | 1207 | 1253 | 1304 |
| | | | | | 26 | .... | .... | .... | 1222 | 1271 | 1326 |
| | | | | | 28 | .... | .... | 1190 | 1236 | 1289 | 1348 |
| | | | | | 30 | .... | .... | 1200 | 1250 | 1307 | 1371 |



# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS CHICAGO BUILDING CODE REQUIREMENTS

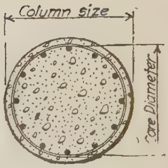
$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$Max.\left(\frac{length}{diameter}\right) = 12$$

*1:1:2 mixture*
$n = 10$
$f_c = 725$

| Size of column (inches) | Diameter of core (inches) | Spirals: Size No. (A. S. & W. Co.) | Spirals: Pitch (inches) | Spirals: Per cent of core | Number of rods | Size of vertical round rods: ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 12 | 9 | 1⅛ | 0.5 | 8 | 110 | 118 | | | | |
| | | | | | 10 | 115 | 125 | | | | |
| 16 | 13 | 8 | 1¼ | 0.5 | 8 | 126 | 134 | | | | |
| | | | | | 10 | 131 | 141 | | | | |
| 17 | 14 | 7 | 1⅜ | 0.5 | 8 | 144 | 151 | 161 | | | |
| | | | | | 10 | 148 | 158 | 170 | | | |
| | | | | | 12 | 153 | 164 | | | | |
| | | 0 | 1⅜ | 1.5 | 8 | 175 | 185 | 197 | | | |
| | | | | | 10 | 181 | 193 | 207 | | | |
| | | | | | 12 | 186 | 201 | | | | |
| 18 | 15 | 6 | 1½ | 0.5 | 8 | 162 | 170 | 179 | 190 | | |
| | | | | | 10 | 167 | 177 | 188 | | | |
| | | | | | 12 | 171 | 183 | | | | |
| | | 2/0 | 1½ | 1.5 | 8 | .... | 208 | 219 | 233 | | |
| | | | | | 10 | 204 | 216 | 230 | | | |
| | | | | | 12 | 209 | 224 | | | | |
| 19 | 16 | 6 | 1⅜ | 0.5 | 8 | 182 | 190 | 199 | 210 | 222 | |
| | | | | | 10 | 186 | 196 | 208 | 222 | | |
| | | | | | 12 | 191 | 203 | 217 | | | |
| | | | | | 14 | 195 | 211 | | | | |
| | | 3/0 | 1⅝ | 1.5 | 8 | .... | 232 | 244 | 257 | 272 | |
| | | | | | 10 | 228 | 240 | 254 | 271 | | |
| | | | | | 12 | 233 | 248 | 265 | | | |
| | | | | | 14 | 239 | 257 | | | | |
| 20 | 17 | 5 | 1½ | 0.5 | 8 | 203 | 211 | 220 | 231 | 243 | |
| | | | | | 10 | 208 | 217 | 229 | 243 | | |
| | | | | | 12 | 212 | 224 | 238 | | | |
| | | | | | 14 | 217 | 231 | 247 | | | |
| | | 3/0 | 1⅝ | 1.5 | 8 | .... | 258 | 269 | 283 | 298 | |
| | | | | | 10 | .... | 266 | 280 | 296 | | |
| | | | | | 12 | 259 | 274 | 291 | | | |
| | | | | | 14 | 265 | 282 | 302 | | | |
| 21 | 18 | 4 | 1¾ | 0.5 | 8 | 225 | 234 | 243 | 254 | 266 | 280 |
| | | | | | 10 | 230 | 240 | 252 | 265 | 280 | |
| | | | | | 12 | 235 | 247 | 260 | 277 | | |
| | | | | | 14 | 239 | 254 | 269 | | | |
| | | 3/0 | 1½ | 1.5 | 8 | .... | .... | 297 | 310 | 325 | 342 |
| | | | | | 10 | .... | 293 | 308 | 324 | 343 | |
| | | | | | 12 | .... | 301 | 318 | 338 | | |
| | | | | | 14 | 292 | 310 | 329 | | | |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS CHICAGO BUILDING CODE REQUIREMENTS

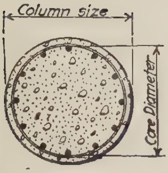


$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

*1:1:2 mixture*
$n = 10$
$f_c = 725$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 22 | 19 | 4 | 1 5/8 | 0.5 | 8 | 249 | 257 | 266 | 277 | 290 | 303 |
| | | | | | 10 | 254 | 264 | 275 | 289 | 304 | |
| | | | | | 12 | 258 | 270 | 284 | 300 | | |
| | | | | | 14 | 263 | 277 | 293 | 312 | | |
| | | | | | 16 | 267 | 283 | 302 | | | |
| | | 4/0 | 1 5/8 | 1.5 | 8 | .... | .... | 326 | 339 | 354 | 370 |
| | | | | | 10 | .... | 322 | 336 | 353 | 372 | |
| | | | | | 12 | .... | 330 | 347 | 367 | | |
| | | | | | 14 | 321 | 338 | 358 | 381 | | |
| | | | | | 16 | 327 | 346 | 369 | | | |
| 23 | 20 | 3 | 1 7/8 | 0.5 | 8 | 274 | 282 | 291 | 302 | 315 | 328 |
| | | | | | 10 | 279 | 289 | 300 | 314 | 329 | 346 |
| | | | | | 12 | 283 | 295 | 309 | 326 | 344 | |
| | | | | | 14 | 288 | 302 | 318 | 337 | | |
| | | | | | 16 | 292 | 308 | 327 | 349 | | |
| | | 5/0 | 1 7/8 | 1.5 | 8 | ... | .... | 356 | 369 | 384 | 401 |
| | | | | | 10 | .... | .... | 367 | 384 | 402 | 423 |
| | | | | | 12 | ... | 361 | 378 | 398 | 420 | |
| | | | | | 14 | .... | 369 | 389 | 412 | | |
| | | | | | 16 | 357 | 377 | 399 | 426 | | |
| 24 | 21 | 3 | 1 3/4 | 0.5 | 10 | 305 | 315 | 326 | 340 | 356 | 372 |
| | | | | | 12 | 309 | 321 | 335 | 352 | 370 | |
| | | | | | 14 | 314 | 328 | 344 | 363 | | |
| | | | | | 16 | 319 | 334 | 353 | 375 | | |
| | | 5/0 | 1 3/4 | 1.5 | 10 | .... | .... | 399 | 416 | 435 | 455 |
| | | | | | 12 | .... | 393 | 410 | 430 | 452 | |
| | | | | | 14 | ... | 401 | 421 | 444 | | |
| | | | | | 16 | .... | 409 | 432 | 458 | | |
| 25 | 22 | 2 | 1 7/8 | 0.5 | 10 | 333 | 342 | 354 | 368 | 383 | 400 |
| | | | | | 12 | 337 | 349 | 363 | 379 | 398 | 418 |
| | | | | | 14 | 341 | 356 | 372 | 391 | 412 | |
| | | | | | 16 | 346 | 362 | 381 | 402 | | |
| | | | | | 18 | 350 | 368 | 389 | 414 | | |
| | | 6/0 | 2 | 1.5 | 10 | ... | .... | 433 | 449 | 468 | 490 |
| | | | | | 12 | .. | .... | 444 | 463 | 486 | 511 |
| | | | | | 14 | ... | 434 | 454 | 478 | 504 | |
| | | | | | 16 | .... | 442 | 465 | 492 | | |
| | | | | | 18 | .... | 450 | 476 | 506 | | |
| 26 | 23 | 2 | 1 7/8 | 0.5 | 10 | 361 | 372 | 383 | 396 | 412 | 429 |
| | | | | | 12 | 366 | 378 | 392 | 408 | 427 | 417 |
| | | | | | 14 | 370 | 385 | 401 | 420 | 442 | |
| | | | | | 16 | 375 | 391 | 410 | 431 | 456 | |
| | | | | | 18 | 379 | 397 | 418 | 443 | | |
| | | 6/0 | 1 7/8 | 1.5 | 10 | .... | .... | ... | 485 | 503 | 525 |
| | | | | | 12 | .. | .... | 479 | 499 | 521 | 546 |
| | | | | | 14 | . | .... | 490 | 513 | 539 | |
| | | | | | 16 | .. | 478 | 501 | 527 | 557 | |
| | | | | | 18 | ... | 485 | 512 | 541 | | |



# ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## CHICAGO BUILDING CODE REQUIREMENTS

$$P = Af_c(1 + 2.5np')[1 + (n-1)p]$$

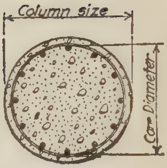
$$Max. \left(\frac{length}{diameter}\right) = 12$$

*1:1:2 mixture*
$n = 10$
$f_c = 725$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 27 | 24 | 1 | 2 | 0.5 | 10 | 392 | 401 | 413 | 427 | 442 | 459 |
| | | | | | 12 | 396 | 408 | 422 | 438 | 457 | 477 |
| | | | | | 14 | 401 | 415 | 431 | 450 | 471 | 495 |
| | | | | | 16 | 305 | 421 | 440 | 461 | 486 | |
| | | | | | 18 | 410 | 428 | 449 | 473 | 500 | |
| | | 7/0 | 2 | 1.5 | 10 | .... | .... | .... | 522 | 540 | 561 |
| | | | | | 12 | .... | .... | 515 | 536 | 558 | 583 |
| | | | | | 14 | .... | .... | 526 | 550 | 576 | 605 |
| | | | | | 16 | .... | 515 | 537 | 564 | 594 | |
| | | | | | 18 | .... | 522 | 548 | 578 | 612 | |
| 28 | 25 | 1 | 2 | 0.5 | 10 | 423 | 433 | 445 | 458 | 473 | 490 |
| | | | | | 12 | 428 | 440 | 453 | 470 | 488 | 508 |
| | | | | | 14 | 432 | 447 | 462 | 481 | 503 | 527 |
| | | | | | 16 | 437 | 453 | 471 | 493 | 517 | 545 |
| | | | | | 18 | 441 | 459 | 480 | 504 | 532 | |
| | | | | | 20 | 446 | 465 | 489 | 516 | | |
| | | 7/0 | 2 | 1.5 | 10 | .... | .... | .... | 560 | 578 | 599 |
| | | | | | 12 | .... | .... | .... | 574 | 596 | 621 |
| | | | | | 14 | .... | .... | 565 | 588 | 614 | 644 |
| | | | | | 16 | .... | .... | 576 | 602 | 632 | 666 |
| | | | | | 18 | .... | 561 | 587 | 616 | 650 | |
| | | | | | 20 | .... | 569 | 597 | 630 | | |
| 29 | 26 | 0 | 2¼ | 0.5 | 12 | 460 | 472 | 486 | 502 | 521 | 541 |
| | | | | | 14 | 464 | 479 | 495 | 513 | 535 | 559 |
| | | | | | 16 | 469 | 485 | 504 | 525 | 550 | 577 |
| | | | | | 18 | 473 | 491 | 512 | 537 | 564 | |
| | | | | | 20 | 478 | 498 | 521 | 548 | 579 | |
| | | 7/0 | 1⅞ | 1.5 | 12 | .... | .... | .... | 613 | 636 | 662 |
| | | | | | 14 | .... | .... | 605 | 628 | 654 | 683 |
| | | | | | 16 | .... | .... | 616 | 642 | 672 | 705 |
| | | | | | 18 | .... | 601 | 626 | 656 | 690 | |
| | | | | | 20 | .... | 608 | 637 | 670 | 707 | |
| 30 | 27 | 0 | 2⅛ | 0.5 | 12 | 494 | 506 | 520 | 536 | 554 | 575 |
| | | | | | 14 | 499 | 513 | 529 | 548 | 569 | 593 |
| | | | | | 16 | 503 | 519 | 537 | 559 | 583 | 611 |
| | | | | | 18 | 508 | 525 | 546 | 570 | 598 | 629 |
| | | | | | 20 | 512 | 531 | 555 | 582 | 613 | |
| | | | | | 22 | 517 | 538 | 564 | 593 | 628 | |
| | | 7/0 | 1⅞ | 1.5 | 12 | .... | .... | .... | 655 | 678 | 703 |
| | | | | | 14 | .... | .... | .... | 670 | 696 | 725 |
| | | | | | 16 | .... | .... | 657 | 684 | 714 | 747 |
| | | | | | 18 | .... | .... | 668 | 698 | 731 | 769 |
| | | | | | 20 | .... | 650 | 679 | 712 | 749 | |
| | | | | | 22 | .... | 658 | 689 | 726 | 767 | |

**COLUMNS**

# ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## CHICAGO BUILDING CODE REQUIREMENTS

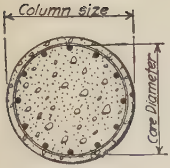


***1:1:2 mixture***
*$n = 10$*
*$f_c = 725$*

$$P = Af_c(1 + 2.5np')[1 + (n - 1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 31 | 28 | 2/0 | 2⅜ | 0.5 | 12 | 530 | 541 | 555 | 571 | 590 | 610 |
| | | | | | 14 | 534 | 548 | 564 | 583 | 605 | 628 |
| | | | | | 16 | 539 | 554 | 573 | 595 | 619 | 647 |
| | | | | | 18 | 543 | 560 | 582 | 606 | 633 | 665 |
| | | | | | 20 | 548 | 567 | 590 | 618 | 648 | 682 |
| | | | | | 22 | 552 | 573 | 599 | 629 | 663 | |
| | | 7/0 | 1¾ | 1.5 | 12 | .... | .... | .... | 698 | 721 | 746 |
| | | | | | 14 | .... | .... | .... | 713 | 739 | 768 |
| | | | | | 16 | .... | .... | 700 | 727 | 757 | 790 |
| | | | | | 18 | .... | .... | 711 | 741 | 775 | 812 |
| | | | | | 20 | .... | .... | 722 | 755 | 792 | 834 |
| | | | | | 22 | .... | 701 | 733 | 769 | 810 | |
| 32 | 29 | 2/0 | 2⅜ | 0.5 | 12 | 565 | 577 | 592 | 608 | 626 | 647 |
| | | | | | 14 | 570 | 584 | 600 | 620 | 641 | 665 |
| | | | | | 16 | 574 | 590 | 609 | 631 | 655 | 683 |
| | | | | | 18 | 579 | 597 | 618 | 642 | 670 | 701 |
| | | | | | 20 | 583 | 603 | 627 | 654 | 685 | 718 |
| | | | | | 22 | 588 | 610 | 636 | 666 | 699 | |
| | | 7/0 | 1⅝ | 1.5 | 12 | .... | .... | .... | .... | 765 | 792 |
| | | | | | 14 | .... | .... | .... | 757 | 783 | 813 |
| | | | | | 16 | .... | .... | .... | 771 | 801 | 835 |
| | | | | | 18 | .... | .... | 756 | 785 | 819 | 857 |
| | | | | | 20 | .... | .... | 767 | 800 | 837 | 879 |
| | | | | | 22 | .... | .... | 777 | 814 | 855 | |
| 33 | 30 | 2/0 | 2¼ | 0.5 | 12 | 604 | 616 | 629 | 646 | 664 | 685 |
| | | | | | 14 | 608 | 622 | 638 | 657 | 678 | 702 |
| | | | | | 16 | 613 | 628 | 647 | 669 | 693 | 720 |
| | | | | | 18 | 617 | 635 | 656 | 680 | 708 | 738 |
| | | | | | 20 | 622 | 641 | 665 | 691 | 723 | 757 |
| | | | | | 22 | 526 | 648 | 674 | 703 | 737 | 775 |
| | | | | | 24 | 631 | 654 | 683 | 715 | 752 | |
| | | 7/0 | 1⅝ | 1.5 | 12 | .... | .... | .... | .... | 812 | 836 |
| | | | | | 14 | .... | .... | .... | 803 | 830 | 858 |
| | | | | | 16 | .... | .... | .... | 817 | 848 | 880 |
| | | | | | 18 | .... | .... | 802 | 832 | 866 | 902 |
| | | | | | 20 | .... | .... | 813 | 846 | 883 | 925 |
| | | | | | 22 | .... | .... | 824 | 860 | 901 | 947 |
| | | | | | 24 | .... | 800 | 834 | 873 | 919 | |
| 34 | 31 | 3/0 | 2⅝ | 0.5 | 14 | 647 | 661 | 677 | 696 | 718 | 742 |
| | | | | | 16 | 652 | 668 | 686 | 708 | 733 | 760 |
| | | | | | 18 | 656 | 674 | 695 | 720 | 747 | 778 |
| | | | | | 20 | 661 | 680 | 704 | 731 | 762 | 796 |
| | | | | | 22 | 665 | 687 | 713 | 743 | 777 | 813 |
| | | | | | 24 | 670 | 693 | 722 | 754 | 791 | 831 |
| | | 7/0 | 1⅝ | 1.5 | 14 | .... | .... | .... | 851 | 878 | 907 |
| | | | | | 16 | .... | .... | .... | 865 | 895 | 929 |
| | | | | | 18 | .... | .... | 850 | 880 | 913 | 951 |
| | | | | | 20 | .... | .... | 861 | 894 | 931 | 973 |
| | | | | | 22 | .... | .... | 872 | 908 | 949 | 995 |
| | | | | | 24 | .... | .... | 882 | 922 | 966 | 1017 |



# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS

$$P=Af_c(1+2.5np')[1+(n-1)p]$$

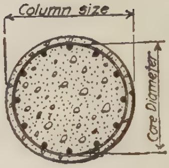
$$\mathit{Max.}\left(\frac{length}{diameter}\right)=12$$

*1:1:2 mixture*
$n=10$
$f_c=725$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 35 | 32 | 3/0 | 2½ | 0.5 | 14 | 688 | 702 | 717 | 737 | 758 | 782 |
| | | | | | 16 | 692 | 708 | 727 | 748 | 773 | 800 |
| | | | | | 18 | 697 | 715 | 736 | 760 | 787 | 818 |
| | | | | | 20 | 701 | 721 | 745 | 771 | 802 | 836 |
| | | | | | 22 | 706 | 728 | 753 | 782 | 817 | 854 |
| | | | | | 24 | 710 | 734 | 762 | 795 | 831 | 872 |
| | | 7/0 | 1½ | 1.5 | 14 | .... | .... | .... | .... | 927 | 956 |
| | | | | | 16 | .... | .... | .... | 915 | 945 | 978 |
| | | | | | 18 | .... | .... | .... | 929 | 963 | 1000 |
| | | | | | 20 | .... | .... | .... | 943 | 981 | 1022 |
| | | | | | 22 | .... | .... | 921 | 957 | 998 | 1045 |
| | | | | | 24 | .... | .... | 931 | 972 | 1016 | 1067 |
| 36 | 33 | 3/0 | 2½ | 0.5 | 14 | 729 | 743 | 759 | 778 | 800 | 824 |
| | | | | | 16 | 734 | 749 | 768 | 790 | 814 | 842 |
| | | | | | 18 | 738 | 756 | 777 | 801 | 829 | 860 |
| | | | | | 20 | 743 | 762 | 786 | 813 | 843 | 878 |
| | | | | | 22 | 747 | 769 | 795 | 825 | 858 | 896 |
| | | | | | 24 | 752 | 775 | 804 | 836 | 873 | 914 |
| | | | | | 26 | 756 | 782 | 812 | 848 | 887 | 932 |
| | | 7/0 | 1½ | 1.5 | 14 | .... | .... | .... | .... | 978 | 1007 |
| | | | | | 16 | .... | .... | .... | .... | 996 | 1029 |
| | | | | | 18 | .... | .... | .... | 980 | 1013 | 1051 |
| | | | | | 20 | .... | .... | .... | 994 | 1031 | 1073 |
| | | | | | 22 | .... | .... | 972 | 1008 | 1049 | 1095 |
| | | | | | 24 | .... | .... | 983 | 1022 | 1067 | 1117 |
| | | | | | 26 | .... | .... | 993 | 1036 | 1086 | 1140 |
| 37 | 34 | 3/0 | 2⅜ | 0.5 | 14 | .... | 787 | 803 | 821 | 843 | 867 |
| | | | | | 16 | 778 | 793 | 812 | 833 | 858 | 885 |
| | | | | | 18 | 782 | 800 | 820 | 844 | 872 | 903 |
| | | | | | 20 | 787 | 806 | 829 | 856 | 886 | 920 |
| | | | | | 22 | 791 | 813 | 838 | 867 | 900 | 938 |
| | | | | | 24 | 796 | 819 | 846 | 879 | 915 | 956 |
| | | | | | 26 | 800 | 826 | 855 | 890 | 930 | 975 |
| | | 7/0 | 1½ | 1.48 | 14 | .... | .... | .... | .... | 1027 | 1054 |
| | | | | | 16 | .... | .... | .... | .... | 1044 | 1077 |
| | | | | | 18 | .... | .... | .... | 1028 | 1061 | 1099 |
| | | | | | 20 | .... | .... | .... | 1042 | 1079 | 1121 |
| | | | | | 22 | .... | .... | .... | 1056 | 1097 | 1143 |
| | | | | | 24 | .... | .... | 1030 | 1070 | 1114 | 1165 |
| | | | | | 26 | .... | .... | 1041 | 1084 | 1132 | 1187 |
| 38 | 35 | 3/0 | 2⅜ | 0.5 | 14 | .... | 830 | 846 | 866 | 887 | 911 |
| | | | | | 16 | 821 | 837 | 854 | 877 | 901 | 929 |
| | | | | | 18 | 826 | 843 | 863 | 888 | 916 | 947 |
| | | | | | 20 | 830 | 850 | 872 | 900 | 930 | 965 |
| | | | | | 22 | 835 | 856 | 881 | 912 | 945 | 983 |
| | | | | | 24 | 839 | 863 | 890 | 923 | 960 | 1000 |
| | | | | | 26 | 844 | 869 | 899 | 935 | 975 | 1018 |
| | | 7/0 | 1½ | 1.43 | 14 | .... | .... | .... | .... | 1072 | 1100 |
| | | | | | 16 | .... | .... | .... | .... | 1089 | 1122 |
| | | | | | 18 | .... | .... | .... | 1073 | 1107 | 1144 |
| | | | | | 20 | .... | .... | .... | 1087 | 1125 | 1166 |
| | | | | | 22 | .... | .... | .... | 1101 | 1142 | 1188 |
| | | | | | 24 | .... | .... | 1075 | 1115 | 1160 | 1209 |
| | | | | | 26 | .... | .... | 1086 | 1129 | 1178 | 1231 |

TABLE 42

# ROUND CORED HOOPED COLUMNS
# SAFE LOAD IN THOUSANDS OF POUNDS
# CHICAGO BUILDING CODE REQUIREMENTS



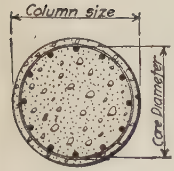
$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$\text{Max.}\left(\frac{\text{length}}{\text{diameter}}\right) = 12$$

*1:1:2 mixture*
*$n = 10$*
*$f_c = 725$*

| Size of column (inches) | Diameter of core (inches) | Spirals |  |  | Number of rods | Size of vertical round rods |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core |  | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 39 | 36 | 4/0 | 2⅝ | 0.5 | 16 | 866 | 882 | 901 | 922 | 947 | 974 |
|  |  |  |  |  | 18 | 871 | 888 | 910 | 934 | 961 | 992 |
|  |  |  |  |  | 20 | 875 | 895 | 919 | 945 | 976 | 1010 |
|  |  |  |  |  | 22 | 880 | 901 | 928 | 957 | 991 | 1028 |
|  |  |  |  |  | 24 | 884 | 908 | 936 | 969 | 1005 | 1046 |
|  |  |  |  |  | 26 | 889 | 914 | 945 | 980 | 1020 | 1064 |
|  |  |  |  |  | 28 | 893 | 920 | 954 | 992 | 1034 | 1082 |
|  |  | 7/0 | 1½ | 1.40 | 16 | .... | .... | .... | .... | 1133 | 1167 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1151 | 1188 |
|  |  |  |  |  | 20 | .... | .... | .... | 1132 | 1168 | 1210 |
|  |  |  |  |  | 22 | .... | .... | .... | 1146 | 1186 | 1232 |
|  |  |  |  |  | 24 | .... | .... | 1121 | 1159 | 1204 | 1254 |
|  |  |  |  |  | 26 | .... | .... | 1131 | 1173 | 1221 | 1275 |
|  |  |  |  |  | 28 | .... | .... | 1141 | 1187 | 1239 | 1297 |
| 40 | 37 | 4/0 | 2⅝ | 0.5 | 16 | .... | 929 | 948 | 968 | 993 | 1021 |
|  |  |  |  |  | 18 | 918 | 935 | 956 | 980 | 1008 | 1039 |
|  |  |  |  |  | 20 | 922 | 942 | 965 | 991 | 1023 | 1057 |
|  |  |  |  |  | 22 | 927 | 948 | 974 | 1003 | 1037 | 1075 |
|  |  |  |  |  | 24 | 931 | 955 | 983 | 1015 | 1052 | 1093 |
|  |  |  |  |  | 26 | 936 | 961 | 991 | 1026 | 1066 | 1111 |
|  |  |  |  |  | 28 | 940 | 967 | 1000 | 1038 | 1081 | 1129 |
|  |  | 7/0 | 1½ | 1.36 | 16 | .... | .... | .... | .... | 1183 | 1216 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1201 | 1237 |
|  |  |  |  |  | 20 | .... | .... | .... | 1181 | 1219 | 1259 |
|  |  |  |  |  | 22 | .... | .... | .... | 1195 | 1236 | 1280 |
|  |  |  |  |  | 24 | .... | .... | .... | 1209 | 1253 | 1302 |
|  |  |  |  |  | 26 | .... | .... | 1181 | 1223 | 1271 | 1323 |
|  |  |  |  |  | 28 | .... | .... | 1191 | 1237 | 1289 | 1345 |
| 41 | 38 | 4/0 | 2½ | 0.5 | 16 | .... | 978 | 996 | 1017 | 1041 | 1069 |
|  |  |  |  |  | 18 | .... | 984 | 1005 | 1029 | 1056 | 1087 |
|  |  |  |  |  | 20 | 971 | 991 | 1013 | 1040 | 1071 | 1105 |
|  |  |  |  |  | 22 | 976 | 997 | 1022 | 1052 | 1086 | 1123 |
|  |  |  |  |  | 24 | 980 | 1004 | 1031 | 1063 | 1100 | 1141 |
|  |  |  |  |  | 26 | 985 | 1010 | 1040 | 1075 | 1115 | 1159 |
|  |  |  |  |  | 28 | 989 | 1016 | 1049 | 1086 | 1130 | 1177 |
|  |  |  |  |  | 30 | 994 | 1022 | 1058 | 1098 | 1144 | 1196 |
|  |  | 7/0 | 1½ | 1.32 | 16 | .... | .... | .... | .... | 1232 | 1264 |
|  |  |  |  |  | 18 | .... | .... | .... | .... | 1249 | 1285 |
|  |  |  |  |  | 20 | .... | .... | .... | 1230 | 1266 | 1306 |
|  |  |  |  |  | 22 | .... | .... | .... | 1244 | 1284 | 1328 |
|  |  |  |  |  | 24 | .... | .... | .... | 1257 | 1301 | 1350 |
|  |  |  |  |  | 26 | .... | .... | 1230 | 1271 | 1318 | 1371 |
|  |  |  |  |  | 28 | .... | .... | 1240 | 1285 | 1336 | 1393 |
|  |  |  |  |  | 30 | .... | .... | 1251 | 1298 | 1353 | 1415 |

TABLE 42



## ROUND CORED HOOPED COLUMNS
## SAFE LOAD IN THOUSANDS OF POUNDS
## CHICAGO BUILDING CODE REQUIREMENTS

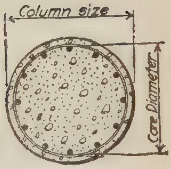
$$P = Af_c(1+2.5np')[1+(n-1)p]$$

$$Max.\left(\frac{length}{diameter}\right) = 12$$

*1:1:2 mixture*
$n = 10$
$f_c = 725$

| Size of column (inches) | Diameter of core (inches) | Spirals | | | Number of rods | Size of vertical round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size No. (A. S. & W. Co.) | Pitch (inches) | Per cent of core | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 42 | 39 | 4/0 | 2½ | 0.5 | 16 | .... | 1027 | 1045 | 1067 | 1091 | 1118 |
| | | | | | 18 | .... | 1033 | 1054 | 1078 | 1106 | 1136 |
| | | | | | 20 | 1020 | 1040 | 1063 | 1090 | 1120 | 1154 |
| | | | | | 22 | 1025 | 1046 | 1071 | 1101 | 1135 | 1172 |
| | | | | | 24 | 1029 | 1053 | 1080 | 1112 | 1149 | 1190 |
| | | | | | 26 | 1034 | 1059 | 1089 | 1124 | 1163 | 1208 |
| | | | | | 28 | 1038 | 1065 | 1098 | 1136 | 1178 | 1226 |
| | | | | | 30 | 1042 | 1072 | 1107 | 1147 | 1193 | 1244 |
| | | 7/0 | 1½ | 1.29 | 16 | .... | .... | .... | .... | 1283 | 1315 |
| | | | | | 18 | .... | .... | .... | .... | 1300 | 1336 |
| | | | | | 20 | .... | .... | .... | 1281 | 1317 | 1357 |
| | | | | | 22 | .... | .... | .... | 1294 | 1334 | 1378 |
| | | | | | 24 | .... | .... | .... | 1308 | 1351 | 1399 |
| | | | | | 26 | .... | .... | 1280 | 1321 | 1368 | 1420 |
| | | | | | 28 | .... | .... | 1290 | 1335 | 1386 | 1441 |
| | | | | | 30 | .... | .... | 1300 | 1349 | 1403 | 1463 |
| 43 | 40 | 4/0 | 2⅜ | 0.5 | 16 | .... | 1077 | 1096 | 1117 | 1142 | 1169 |
| | | | | | 18 | .... | 1083 | 1104 | 1129 | 1156 | 1187 |
| | | | | | 20 | .... | 1090 | 1113 | 1140 | 1171 | 1205 |
| | | | | | 22 | 1073 | 1096 | 1122 | 1152 | 1186 | 1223 |
| | | | | | 24 | 1078 | 1103 | 1131 | 1163 | 1200 | 1241 |
| | | | | | 26 | 1083 | 1109 | 1140 | 1175 | 1215 | 1259 |
| | | | | | 28 | 1088 | 1116 | 1149 | 1186 | 1229 | 1277 |
| | | | | | 30 | 1092 | 1122 | 1158 | 1198 | 1244 | 1295 |
| | | 7/0 | 1½ | 1.25 | 16 | .... | .... | .... | .... | 1333 | 1366 |
| | | | | | 18 | .... | .... | .... | .... | 1350 | 1387 |
| | | | | | 20 | .... | .... | .... | 1332 | 1367 | 1408 |
| | | | | | 22 | .... | .... | .... | 1345 | 1385 | 1429 |
| | | | | | 24 | .... | .... | .... | 1359 | 1402 | 1450 |
| | | | | | 26 | .... | .... | .... | 1372 | 1419 | 1471 |
| | | | | | 28 | .... | .... | 1340 | 1386 | 1436 | 1492 |
| | | | | | 30 | .... | .... | 1350 | 1400 | 1453 | 1513 |

# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS LOS ANGELES AND MILWAUKEE BUILDING CODE REQUIREMENTS



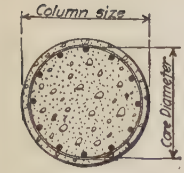
$n=15$
$f_c=800$

$$P=Af_c[1+(n-1)p]$$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 10 | 7 | 6 | *57.0 | ..... | ..... | ..... | ..... | ..... | *51.4 | *60.5 | | | | |
| 11 | 8 | 6 | *66.4 | *78.0 | ..... | ..... | ..... | ..... | 60.8 | *69.9 | | | | |
| | | 8 | *75.2 | ..... | ..... | ..... | ..... | ..... | *67.7 | *79.8 | | | | |
| 12 | 9 | 6 | 77.1 | ..... | ..... | ..... | ..... | ..... | 71.5 | | | | | |
| | | 8 | ..... | ..... | ..... | ..... | ..... | ..... | 78.4 | | | | | |
| 13 | 10 | 6 | 89.0 | ..... | ..... | ..... | ..... | ..... | 83.4 | 92.5 | | | | |
| | | 8 | 97.8 | ..... | ..... | ..... | ..... | ..... | 90.3 | | | | | |
| 14 | 11 | 6 | 102.2 | 113.8 | ..... | ..... | ..... | ..... | 96.6 | 105.7 | 116.4 | | | |
| | | 8 | 111.0 | ..... | ..... | ..... | ..... | ..... | 103.5 | 115.6 | | | | |
| | | 10 | ..... | ..... | ..... | ..... | ..... | ..... | 110.4 | | | | | |
| 15 | 12 | 6 | 116.7 | 128.3 | ..... | ..... | ..... | ..... | 111.1 | 120.2 | 130.9 | | | |
| | | 8 | 125.5 | 140.9 | ..... | ..... | ..... | ..... | 118.0 | 130.1 | | | | |
| | | 10 | 134.3 | ..... | ..... | ..... | ..... | ..... | 124.9 | 140.0 | | | | |
| 16 | 13 | 6 | 132.4 | 144.0 | 157.6 | ..... | ..... | ..... | 126.8 | 135.9 | 146.6 | 159.0 | | |
| | | 8 | 141.2 | 156.6 | ..... | ..... | ..... | ..... | 133.7 | 145.8 | 160.1 | | | |
| | | 10 | 150.0 | ..... | ..... | ..... | ..... | ..... | 140.6 | 155.7 | | | | |
| 17 | 14 | 6 | 149.3 | 160.9 | 174.5 | 190.3 | ..... | ..... | 143.7 | 152.8 | 163.5 | 175.9 | 189.9 | |
| | | 8 | 158.1 | 173.5 | 191.7 | ..... | ..... | ..... | 150.6 | 162.7 | 177.0 | | | |
| | | 10 | 166.9 | 186.1 | ..... | ..... | ..... | ..... | 157.5 | 172.6 | 190.4 | | | |
| | | 12 | 175.6 | ..... | ..... | ..... | ..... | ..... | 164.3 | 182.5 | | | | |
| 18 | 15 | 6 | 167.6 | 179.2 | 192.8 | 208.6 | ..... | ..... | 162.0 | 171.0 | 181.8 | 194.2 | | |
| | | 8 | 176.4 | 191.8 | 210.0 | ..... | ..... | ..... | 168.9 | 181.0 | 195.3 | 211.8 | | |
| | | 10 | 185.2 | 204.4 | ..... | ..... | ..... | ..... | 175.8 | 190.9 | 208.7 | | | |
| | | 12 | 193.9 | 217.0 | ..... | ..... | ..... | ..... | 182.6 | 200.8 | | | | |
| 19 | 16 | 8 | 195.9 | 211.3 | 229.5 | 250.5 | ..... | ..... | 188.4 | 200.5 | 214.8 | 231.3 | 250.0 | |
| | | 10 | 204.7 | 223.9 | 246.6 | ..... | ..... | ..... | 195.3 | 210.4 | 228.2 | 248.9 | | |
| | | 12 | 213.4 | 236.5 | ..... | ..... | ..... | ..... | 202.1 | 220.3 | 241.7 | | | |
| | | 14 | 222.2 | 249.1 | ..... | ..... | ..... | ..... | 209.0 | 230.2 | | | | |
| 20 | 17 | 8 | 216.6 | 232.0 | 250.2 | 271.2 | ..... | ..... | 209.1 | 221.2 | 235.5 | 252.0 | 270.7 | |
| | | 10 | 225.4 | 244.6 | 267.3 | ..... | ..... | ..... | 216.0 | 231.1 | 248.9 | 269.6 | | |
| | | 12 | 234.1 | 257.2 | ..... | ..... | ..... | ..... | 222.8 | 241.0 | 262.4 | | | |
| | | 14 | 242.9 | 269.8 | ..... | ..... | ..... | ..... | 229.7 | 250.9 | 275.9 | | | |
| 21 | 18 | 8 | 238.6 | 254.0 | 272.2 | 293.2 | 317.0 | ..... | ..... | 243.2 | 257.5 | 274.0 | 292.7 | 313.5 |
| | | 10 | 247.4 | 266.6 | 289.3 | 315.6 | ..... | ..... | 238.0 | 253.1 | 270.9 | 291.6 | 314.9 | |
| | | 12 | 256.1 | 279.2 | 306.5 | ..... | ..... | ..... | 244.8 | 263.0 | 284.4 | 309.2 | | |
| | | 14 | 264.9 | 291.8 | ..... | ..... | ..... | ..... | 251.7 | 272.9 | 297.9 | | | |
| 22 | 19 | 8 | 261.8 | 277.2 | 295.4 | 316.4 | 340.2 | ..... | ..... | 266.4 | 280.7 | 297.2 | 315.9 | 336.7 |
| | | 10 | 270.6 | 289.8 | 312.5 | 338.8 | ..... | ..... | 261.2 | 276.3 | 294.1 | 314.8 | 338.1 | |
| | | 12 | 279.3 | 302.4 | 329.7 | ..... | ..... | ..... | 268.0 | 286.2 | 307.6 | 332.4 | | |
| | | 14 | 288.1 | 315.0 | 346.8 | ..... | ..... | ..... | 274.9 | 296.1 | 321.1 | 350.0 | | |
| | | 16 | 296.8 | 327.6 | ..... | ..... | ..... | ..... | 281.8 | 306.0 | 334.6 | | | |
| 23 | 20 | 8 | 286.4 | 301.8 | 320.0 | 341.0 | 364.8 | 391.4 | ..... | 291.0 | 305.3 | 321.8 | 340.5 | 361.3 |
| | | 10 | 295.2 | 314.4 | 337.1 | 363.4 | 393.1 | ..... | ..... | 300.9 | 318.7 | 339.4 | 362.7 | 388.8 |
| | | 12 | 303.9 | 327.0 | 354.3 | 385.8 | ..... | ..... | 292.6 | 310.8 | 332.2 | 357.0 | 385.0 | |
| | | 14 | 312.7 | 339.6 | 371.4 | ..... | ..... | ..... | 299.5 | 320.7 | 345.7 | 374.6 | | |
| | | 16 | 321.4 | 352.2 | 388.6 | ..... | ..... | ..... | 306.4 | 330.6 | 359.2 | 392.1 | | |

* These columns contain more than 4% of steel.

TABLE 43



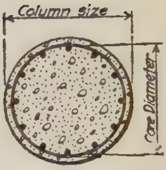
# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS LOS ANGELES AND MILWAUKEE BUILDING CODE REQUIREMENTS

$$P = Af_c[1+(n-1)p]$$

$n = 15$
$f_c = 800$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 24 | 21 | 10 | 320.9 | 340.1 | 362.8 | 389.1 | 418.8 | ..... | ..... | 326.6 | 344.4 | 265.1 | 388.4 | 414.5 |
| | | 12 | 329.6 | 352.7 | 380.0 | 411.5 | ..... | ..... | 318.3 | 336.5 | 357.9 | 382.7 | 410.7 | |
| | | 14 | 338.4 | 365.3 | 397.1 | ..... | ..... | ..... | 325.2 | 346.4 | 371.4 | 400.3 | | |
| | | 16 | 347.1 | 377.9 | 414.3 | ..... | ..... | ..... | 332.1 | 356.3 | 384.9 | 417.8 | | |
| 25 | 22 | 10 | 347.9 | 367.1 | 389.8 | 416.1 | 445.8 | ..... | ..... | 353.6 | 371.4 | 392.1 | 415.4 | 441.5 |
| | | 12 | 356.6 | 379.7 | 407.0 | 438.5 | 474.2 | ..... | ..... | 363.5 | 384.9 | 409.7 | 437.7 | 469.0 |
| | | 14 | 365.4 | 392.3 | 424.1 | 460.9 | ..... | ..... | 352.2 | 373.4 | 398.4 | 427.3 | 460.0 | |
| | | 16 | 374.1 | 404.9 | 441.3 | ..... | ..... | ..... | 359.1 | 383.3 | 411.9 | 444.8 | | |
| | | 18 | 382.9 | 417.5 | 458.4 | ..... | ..... | ..... | 366.0 | 393.2 | 425.3 | 462.4 | | |
| 26 | 23 | 10 | ..... | 395.4 | 418.1 | 444.4 | 474.1 | 507.4 | ..... | 381.9 | 399.7 | 420.4 | 443.7 | 469.8 |
| | | 12 | ..... | 408.0 | 435.3 | 466.8 | 502.5 | ..... | ..... | 391.8 | 413.2 | 438.0 | 466.0 | 497.3 |
| | | 14 | ..... | 420.6 | 452.4 | 489.2 | ..... | ..... | ..... | 401.7 | 426.7 | 455.6 | 488.3 | |
| | | 16 | ..... | 433.2 | 469.6 | 511.6 | ..... | ..... | ..... | 411.6 | 440.2 | 473.1 | 510.5 | |
| | | 18 | ..... | 445.8 | 486.7 | ..... | ..... | ..... | ..... | 421.5 | 453.6 | 490.7 | | |
| 27 | 24 | 10 | ..... | 424.9 | 447.6 | 473.9 | 503.6 | 536.9 | ..... | ..... | 429.2 | 449.9 | 473.2 | 499.3 |
| | | 12 | ..... | 437.5 | 464.8 | 496.3 | 532.0 | ..... | ..... | 421.3 | 442.7 | 467.5 | 495.5 | 526.8 |
| | | 14 | ..... | 450.1 | 481.9 | 518.7 | 560.3 | ..... | ..... | 431.2 | 456.2 | 485.1 | 517.8 | 554.3 |
| | | 16 | ..... | 462.7 | 499.1 | 541.1 | ..... | ..... | ..... | 441.1 | 469.7 | 502.6 | 540.0 | |
| | | 18 | ..... | 475.3 | 516.2 | 563.5 | ..... | ..... | ..... | 451.0 | 483.1 | 520.2 | 562.3 | |
| 28 | 25 | 10 | ..... | 455.7 | 478.4 | 504.7 | 534.4 | 567.7 | ..... | ..... | 460.0 | 480.7 | 504.0 | 530.1 |
| | | 12 | ..... | 468.3 | 495.6 | 527.1 | 562.8 | 602.7 | .... | 452.1 | 473.5 | 498.3 | 526.3 | 557.6 |
| | | 14 | ..... | 480.9 | 512.7 | 549.5 | 591.1 | ..... | ..... | 462.0 | 487.0 | 515.9 | 548.6 | 585.1 |
| | | 16 | ..... | 493.5 | 529.9 | 571.9 | ..... | ..... | ..... | 471.9 | 500.5 | 533.4 | 570.8 | 612.6 |
| | | 18 | ..... | 506.1 | 547.0 | 594.3 | ..... | ..... | ..... | 481.8 | 513.9 | 551.0 | 593.1 | |
| | | 20 | .... | 518.7 | 564.2 | ..... | ..... | ..... | ..... | 491.7 | 527.4 | 568.6 | | |
| 29 | 26 | 12 | ..... | 500.3 | 527.6 | 559.1 | 594.8 | 634.7 | ..... | 484.1 | 505.5 | 530.3 | 558.3 | 589.6 |
| | | 14 | ..... | 512.9 | 544.7 | 581.5 | 623.1 | ..... | ..... | 494.0 | 519.0 | 547.9 | 580.6 | 617.1 |
| | | 16 | ..... | 525.5 | 561.9 | 603.9 | 651.5 | ..... | ..... | 503.9 | 532.5 | 565.4 | 602.8 | 644.6 |
| | | 18 | ..... | 538.1 | 579.0 | 626.3 | ..... | ..... | ..... | 513.8 | 545.9 | 583.0 | 625.1 | |
| | | 20 | ..... | 550.7 | 596.2 | 648.7 | ..... | ..... | ..... | 523.7 | 559.4 | 600.6 | 647.4 | |
| 30 | 27 | 12 | ..... | 533.7 | 561.0 | 592.5 | 628.2 | 668.1 | ..... | ..... | 538.9 | 563.7 | 591.7 | 623.0 |
| | | 14 | ..... | 546.3 | 578.1 | 614.9 | 656.5 | 703.1 | ..... | 527.4 | 552.4 | 581.3 | 614.0 | 650.5 |
| | | 16 | ..... | 558.9 | 595.3 | 637.3 | 684.9 | ..... | ..... | 537.3 | 565.9 | 598.8 | 636.2 | 678.0 |
| | | 18 | ..... | 571.5 | 612.4 | 659.7 | 713.2 | ..... | ..... | 547.2 | 579.3 | 616.4 | 658.5 | 705.5 |
| | | 20 | ..... | 584.1 | 629.6 | 682.1 | ..... | ..... | ..... | 557.1 | 592.8 | 634.0 | 680.8 | |
| | | 22 | ..... | 596.7 | 646.7 | 704.5 | ..... | ..... | ..... | 567.0 | 606.3 | 651.6 | 703.0 | |
| 31 | 28 | 12 | ..... | 568.2 | 595.5 | 627.0 | 662.7 | 702.6 | ..... | ..... | 573.4 | 598.2 | 626.2 | 657.5 |
| | | 14 | ..... | 580.8 | 612.6 | 649.4 | 691.0 | 737.6 | ..... | 561.9 | 586.9 | 615.8 | 648.5 | 685.0 |
| | | 16 | ..... | 593.4 | 629.8 | 671.8 | 719.4 | ..... | ..... | 571.8 | 600.4 | 633.3 | 670.7 | 712.5 |
| | | 18 | ..... | 606.0 | 646.9 | 694.2 | 747.7 | ..... | ..... | 581.7 | 613.8 | 650.9 | 693.0 | 740.0 |
| | | 20 | ..... | 618.6 | 664.1 | 716.6 | ..... | ..... | ..... | 591.6 | 627.3 | 668.5 | 715.3 | 767.4 |
| | | 22 | ..... | 631.2 | 681.2 | 739.0 | ..... | ..... | ..... | 601.5 | 640.8 | 686.1 | 737.5 | |
| 32 | 29 | 12 | ..... | 604.0 | 631.3 | 662.8 | 698.5 | 738.4 | ..... | ..... | 609.2 | 634.0 | 662.0 | 693.3 |
| | | 14 | ..... | 616.6 | 648.4 | 685.2 | 726.8 | 773.4 | ..... | ..... | 622.7 | 651.6 | 684.3 | 720.8 |
| | | 16 | ..... | 629.2 | 665.6 | 707.6 | 755.2 | 808.4 | ..... | 607.6 | 636.2 | 669.1 | 706.5 | 748.3 |
| | | 18 | ..... | 641.8 | 682.7 | 730.0 | 783.5 | ..... | ..... | 617.5 | 649.6 | 686.7 | 728.8 | 775.8 |
| | | 20 | ..... | 654.4 | 699.9 | 752.4 | 811.9 | ..... | ..... | 627.4 | 663.1 | 704.3 | 751.1 | 803.2 |
| | | 22 | ..... | 667.0 | 717.0 | 774.8 | ..... | ..... | ..... | 637.3 | 676.6 | 721.9 | 773.3 | |
| 33 | 30 | 12 | ..... | ..... | 668.4 | 699.9 | 735.6 | 775.5 | ..... | ..... | 646.3 | 671.1 | 699.1 | 730.4 |
| | | 14 | .... | 653.7 | 685.5 | 722.3 | 763.9 | 810.5 | ..... | ..... | 659.8 | 688.7 | 721.4 | 757.9 |
| | | 16 | ..... | 666.3 | 702.7 | 744.7 | 792.3 | 845.5 | ..... | 644.7 | 673.3 | 706.2 | 743.6 | 785.4 |
| | | 18 | ..... | 678.9 | 719.8 | 767.1 | 820.6 | 880.5 | ..... | 654.6 | 686.7 | 723.8 | 765.9 | 812.9 |
| | | 20 | ..... | 691.5 | 737.0 | 789.5 | 849.0 | ..... | ..... | 664.5 | 700.2 | 741.4 | 788.2 | 840.3 |
| | | 22 | ..... | 704.1 | 754.1 | 811.9 | 877.3 | ..... | ..... | 674.4 | 713.7 | 759.0 | 810.4 | 867.8 |
| | | 24 | ..... | 716.7 | 771.3 | 834.3 | ..... | ..... | ..... | 684.3 | 727.1 | 776.6 | 832.7 | |

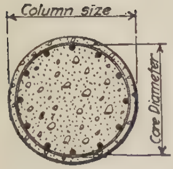
# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS LOS ANGELES AND MILWAUKEE BUILDING CODE REQUIREMENTS



$n = 15$
$f_c = 800$

$$P = Af_c[1 + (n - 1)p]$$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| 34 | 31 | 14 | ..... | 692.0 | 723.8 | 760.6 | 802.2 | 848.8 | ..... | ..... | 698.1 | 727.0 | 759.7 | 796.2 |
| | | 16 | ..... | 704.6 | 741.0 | 783.0 | 830.6 | 883.8 | ..... | ..... | 711.6 | 744.5 | 781.9 | 823.7 |
| | | 18 | ..... | 717.2 | 758.1 | 805.4 | 858.9 | 918.8 | ..... | 692.9 | 725.0 | 762.1 | 804.2 | 851.2 |
| | | 20 | ..... | 729.8 | 775.3 | 827.8 | 887.3 | ..... | ..... | 702.8 | 738.5 | 779.7 | 826.5 | 878.6 |
| | | 22 | ..... | 742.4 | 792.4 | 850.2 | 915.6 | ..... | ..... | 712.7 | 752.0 | 797.3 | 848.7 | 906.1 |
| | | 24 | ..... | 755.0 | 809.6 | 872.6 | ..... | ..... | ..... | 722.6 | 765.4 | 814.9 | 871.0 | 933.6 |
| 35 | 32 | 14 | ..... | ..... | 763.4 | 800.2 | 841.8 | 888.4 | ..... | ..... | 737.7 | 766.6 | 799.3 | 835.8 |
| | | 16 | ..... | ..... | 780.6 | 822.6 | 870.2 | 923.4 | ..... | ..... | 751.2 | 784.1 | 821.5 | 863.3 |
| | | 18 | ..... | ..... | 797.7 | 845.0 | 898.5 | 958.4 | ..... | ..... | 764.6 | 801.7 | 843.8 | 890.8 |
| | | 20 | ..... | ..... | 814.9 | 867.4 | 926.9 | 993.4 | ..... | ..... | 778.1 | 819.3 | 866.1 | 918.2 |
| | | 22 | ..... | ..... | 832.0 | 889.8 | 955.2 | ..... | ..... | ..... | 791.6 | 836.9 | 888.3 | 945.7 |
| | | 24 | ..... | ..... | 849.2 | 912.2 | 983.6 | ..... | ..... | ..... | 805.0 | 854.5 | 920.6 | 973.2 |
| 36 | 33 | 14 | ..... | ..... | 804.2 | 841.0 | 882.6 | 929.2 | ..... | ..... | ..... | 807.4 | 840.1 | 876.6 |
| | | 16 | ..... | ..... | 821.4 | 863.4 | 911.0 | 964.2 | ..... | ..... | 792.0 | 824.9 | 862.3 | 904.1 |
| | | 18 | ..... | ..... | 838.5 | 885.8 | 939.3 | 999.2 | ..... | ..... | 805.4 | 842.5 | 884.6 | 931.6 |
| | | 20 | ..... | ..... | 855.7 | 908.2 | 967.7 | 1034 | ..... | ..... | 818.9 | 860.1 | 906.9 | 959.0 |
| | | 22 | ..... | ..... | 872.8 | 930.6 | 996.0 | ..... | ..... | ..... | 832.4 | 877.7 | 929.1 | 986.5 |
| | | 24 | ..... | ..... | 890.0 | 953.0 | 1024 | ..... | ..... | ..... | 845.8 | 895.3 | 951.4 | 1014 |
| | | 26 | ..... | ..... | 907.1 | 975.4 | 1053 | ..... | ..... | ..... | 859.3 | 912.9 | 973.7 | 1041 |
| 37 | 34 | 14 | ..... | ..... | 846.3 | 883.1 | 924.7 | 971.3 | ..... | ..... | ..... | 849.5 | 882.2 | 918.7 |
| | | 16 | ..... | ..... | 863.5 | 905.5 | 953.1 | 1006 | ..... | ..... | 834.1 | 867.0 | 904.4 | 946.2 |
| | | 18 | ..... | ..... | 880.6 | 927.9 | 981.4 | 1041 | ..... | ..... | 847.5 | 884.6 | 926.7 | 973.7 |
| | | 20 | ..... | ..... | 897.8 | 950.3 | 1010 | 1076 | ..... | ..... | 861.0 | 902.2 | 949.0 | 1001 |
| | | 22 | ..... | ..... | 914.9 | 972.7 | 1038 | 1111 | ..... | ..... | 874.5 | 919.8 | 971.2 | 1029 |
| | | 24 | ..... | ..... | 932.1 | 995.1 | 1067 | ..... | ..... | ..... | 887.9 | 937.4 | 993.5 | 1056 |
| | | 26 | ..... | ..... | 949.2 | 1018 | 1095 | ..... | ..... | ..... | 901.4 | 955.0 | 1016 | 1084 |
| 38 | 35 | 14 | ..... | ..... | 889.7 | 926.5 | 968.1 | 1015 | ..... | ..... | ..... | 892.9 | 925.6 | 962.1 |
| | | 16 | ..... | ..... | 906.9 | 948.9 | 996.5 | 1050 | ..... | ..... | 877.5 | 910.4 | 947.8 | 989.6 |
| | | 18 | ..... | ..... | 924.0 | 971.3 | 1025 | 1085 | ..... | ..... | 890.9 | 928.0 | 970.1 | 1017 |
| | | 20 | ..... | ..... | 941.2 | 993.7 | 1053 | 1120 | ..... | ..... | 904.4 | 945.6 | 992.4 | 1045 |
| | | 22 | ..... | ..... | 958.3 | 1016 | 1082 | 1155 | ..... | ..... | 917.9 | 963.2 | 1015 | 1072 |
| | | 24 | ..... | ..... | 975.5 | 1039 | 1110 | 1190 | ..... | ..... | 931.3 | 980.8 | 1037 | 1100 |
| | | 26 | ..... | ..... | 992.6 | 1061 | 1138 | ..... | ..... | ..... | 944.8 | 998.4 | 1059 | 1127 |
| 39 | 36 | 16 | ..... | ..... | 951.5 | 993.5 | 1041 | 1094 | ..... | ..... | ..... | 955.0 | 992.4 | 1034 |
| | | 18 | ..... | ..... | 968.6 | 1016 | 1069 | 1129 | ..... | ..... | 935.5 | 972.6 | 1015 | 1062 |
| | | 20 | ..... | ..... | 985.8 | 1038 | 1098 | 1164 | ..... | ..... | 949.0 | 990.2 | 1037 | 1089 |
| | | 22 | ..... | ..... | 1003 | 1061 | 1126 | 1199 | ..... | ..... | 962.5 | 1008 | 1059 | 1117 |
| | | 24 | ..... | ..... | 1020 | 1083 | 1155 | 1234 | ..... | ..... | 975.9 | 1025 | 1082 | 1144 |
| | | 26 | ..... | ..... | 1037 | 1106 | 1183 | 1269 | ..... | ..... | 989.4 | 1043 | 1104 | 1172 |
| | | 28 | ..... | ..... | 1054 | 1128 | 1211 | ..... | ..... | ..... | 1003 | 1061 | 1126 | 1199 |
| 40 | 37 | 16 | ..... | ..... | 997.4 | 1039 | 1087 | 1140 | ..... | ..... | ..... | 1001 | 1038 | 1080 |
| | | 18 | ..... | ..... | 1015 | 1062 | 1115 | 1175 | ..... | ..... | 981.4 | 1019 | 1061 | 1108 |
| | | 20 | ..... | ..... | 1032 | 1084 | 1144 | 1210 | ..... | ..... | 994.9 | 1036 | 1083 | 1135 |
| | | 22 | ..... | ..... | 1049 | 1107 | 1172 | 1245 | ..... | ..... | 1008 | 1054 | 1105 | 1163 |
| | | 24 | ..... | ..... | 1066 | 1129 | 1200 | 1280 | ..... | ..... | 1022 | 1071 | 1127 | 1190 |
| | | 26 | ..... | ..... | 1083 | 1151 | 1229 | 1315 | ..... | ..... | 1035 | 1089 | 1150 | 1218 |
| | | 28 | ..... | ..... | 1100 | 1174 | 1257 | ..... | ..... | ..... | 1049 | 1107 | 1172 | 1245 |
| 41 | 38 | 16 | ..... | ..... | 1045 | 1087 | 1134 | 1187 | ..... | ..... | ..... | 1048 | 1085 | 1127 |
| | | 18 | ..... | ..... | 1062 | 1109 | 1162 | 1222 | ..... | ..... | ..... | 1066 | 1108 | 1155 |
| | | 20 | ..... | ..... | 1079 | 1131 | 1191 | 1257 | ..... | ..... | 1042 | 1083 | 1130 | 1182 |
| | | 22 | ..... | ..... | 1096 | 1154 | 1219 | 1292 | ..... | ..... | 1056 | 1101 | 1152 | 1210 |
| | | 24 | ..... | ..... | 1113 | 1176 | 1248 | 1327 | ..... | ..... | 1069 | 1118 | 1175 | 1237 |
| | | 26 | ..... | ..... | 1130 | 1199 | 1276 | 1362 | ..... | ..... | 1082 | 1136 | 1197 | 1265 |
| | | 28 | ..... | ..... | 1147 | 1221 | 1304 | 1397 | ..... | ..... | 1096 | 1154 | 1219 | 1292 |
| | | 30 | ..... | ..... | 1165 | 1243 | 1333 | ..... | ..... | ..... | 1109 | 1171 | 1241 | 1320 |



# ROUND CORED HOOPED COLUMNS SAFE LOAD IN THOUSANDS OF POUNDS LOS ANGELES AND MILWAUKEE BUILDING CODE REQUIREMENTS

$$P = Af_c[1 + (n - 1)p]$$

$n = 15$
$f_c = 800$

| Size of column (inches) | Diameter of core (inches) | Number of rods | Square rods | | | | | | Round rods | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| 42 | 39 | 16 | | | 1093 | 1135 | 1183 | 1236 | | | | 1096 | 1134 | 1176 |
| | | 18 | | | 1110 | 1157 | 1211 | 1271 | | | | 1114 | 1156 | 1203 |
| | | 20 | | | 1127 | 1180 | 1239 | 1306 | | | 1091 | 1132 | 1178 | 1231 |
| | | 22 | | | 1144 | 1202 | 1268 | 1341 | | | 1104 | 1149 | 1201 | 1258 |
| | | 24 | | | 1162 | 1225 | 1296 | 1376 | | | 1117 | 1167 | 1223 | 1286 |
| | | 26 | | | 1179 | 1247 | 1324 | 1411 | | | 1131 | 1184 | 1245 | 1313 |
| | | 28 | | | 1196 | 1269 | 1353 | 1446 | | | 1144 | 1202 | 1267 | 1341 |
| | | 30 | | | 1213 | 1292 | 1381 | 1481 | | | 1158 | 1220 | 1290 | 1368 |
| 43 | 40 | 16 | | | | 1185 | 1232 | 1285 | | | | 1146 | 1183 | 1225 |
| | | 18 | | | 1160 | 1207 | 1260 | 1320 | | | | 1164 | 1206 | 1253 |
| | | 20 | | | 1177 | 1229 | 1289 | 1355 | | | | 1181 | 1228 | 1280 |
| | | 22 | | | 1194 | 1252 | 1317 | 1390 | | | 1154 | 1199 | 1250 | 1308 |
| | | 24 | | | 1211 | 1274 | 1346 | 1425 | | | 1167 | 1216 | 1273 | 1335 |
| | | 26 | | | 1228 | 1297 | 1374 | 1460 | | | 1180 | 1234 | 1295 | 1363 |
| | | 28 | | | 1245 | 1319 | 1402 | 1495 | | | 1194 | 1252 | 1317 | 1390 |
| | | 30 | | | 1262 | 1341 | 1431 | 1530 | | | 1207 | 1269 | 1339 | 1418 |
| 44 | 41 | 18 | | | 1211 | 1258 | 1311 | 1371 | | | | 1215 | 1257 | 1304 |
| | | 20 | | | 1228 | 1280 | 1340 | 1406 | | | | 1232 | 1279 | 1331 |
| | | 22 | | | 1245 | 1303 | 1368 | 1441 | | | 1204 | 1250 | 1301 | 1359 |
| | | 24 | | | 1262 | 1325 | 1396 | 1476 | | | 1218 | 1267 | 1323 | 1386 |
| | | 26 | | | 1279 | 1347 | 1425 | 1511 | | | 1231 | 1285 | 1346 | 1414 |
| | | 28 | | | 1296 | 1370 | 1453 | 1546 | | | 1245 | 1303 | 1368 | 1441 |
| | | 30 | | | 1313 | 1392 | 1481 | 1581 | | | 1258 | 1320 | 1390 | 1469 |
| 45 | 42 | 18 | | | | 1310 | 1363 | 1423 | | | | 1267 | 1309 | 1356 |
| | | 20 | | | 1280 | 1332 | 1392 | 1458 | | | | 1284 | 1331 | 1383 |
| | | 22 | | | 1297 | 1355 | 1420 | 1493 | | | | 1302 | 1353 | 1411 |
| | | 24 | | | 1314 | 1377 | 1449 | 1528 | | | 1270 | 1319 | 1376 | 1438 |
| | | 26 | | | 1331 | 1400 | 1477 | 1563 | | | 1283 | 1337 | 1398 | 1466 |
| | | 28 | | | 1348 | 1422 | 1505 | 1598 | | | 1297 | 1355 | 1420 | 1493 |
| | | 30 | | | 1366 | 1444 | 1534 | 1633 | | | 1310 | 1372 | 1442 | 1521 |
| 46 | 43 | 18 | | | | 1363 | 1417 | 1477 | | | | | 1362 | 1409 |
| | | 20 | | | 1333 | 1386 | 1445 | 1512 | | | | 1338 | 1385 | 1437 |
| | | 22 | | | 1350 | 1408 | 1474 | 1547 | | | | 1355 | 1407 | 1464 |
| | | 24 | | | 1368 | 1431 | 1502 | 1582 | | | | 1373 | 1429 | 1492 |
| | | 26 | | | 1385 | 1453 | 1530 | 1617 | | | 1337 | 1391 | 1451 | 1519 |
| | | 28 | | | 1402 | 1475 | 1559 | 1652 | | | 1351 | 1408 | 1474 | 1547 |
| | | 30 | | | 1419 | 1498 | 1587 | 1687 | | | 1364 | 1426 | 1496 | 1574 |
| 47 | 44 | 18 | | | | 1418 | 1472 | 1531 | | | | | 1417 | 1464 |
| | | 20 | | | 1388 | 1440 | 1500 | 1566 | | | | 1392 | 1439 | 1491 |
| | | 22 | | | 1405 | 1463 | 1528 | 1601 | | | | 1410 | 1461 | 1519 |
| | | 24 | | | 1422 | 1485 | 1557 | 1636 | | | | 1428 | 1484 | 1546 |
| | | 26 | | | 1439 | 1508 | 1585 | 1671 | | | 1392 | 1445 | 1506 | 1574 |
| | | 28 | | | 1457 | 1530 | 1613 | 1706 | | | 1405 | 1463 | 1528 | 1601 |
| | | 30 | | | 1474 | 1552 | 1642 | 1741 | | | 1418 | 1480 | 1550 | 1629 |
| 48 | 45 | 18 | | | | 1474 | 1527 | 1587 | | | | | 1473 | 1520 |
| | | 20 | | | | 1496 | 1556 | 1622 | | | | | 1495 | 1547 |
| | | 22 | | | 1461 | 1519 | 1584 | 1657 | | | | 1466 | 1517 | 1575 |
| | | 24 | | | 1478 | 1541 | 1613 | 1692 | | | | 1483 | 1540 | 1602 |
| | | 26 | | | 1495 | 1563 | 1641 | 1727 | | | | 1501 | 1562 | 1630 |
| | | 28 | | | 1512 | 1586 | 1669 | 1762 | | | 1461 | 1519 | 1584 | 1657 |
| | | 30 | | | 1530 | 1608 | 1698 | 1797 | | | 1474 | 1536 | 1606 | 1685 |
| 49 | 46 | 20 | | | | 1554 | 1613 | 1680 | | | | | 1552 | 1604 |
| | | 22 | | | 1518 | 1576 | 1641 | 1715 | | | | 1523 | 1574 | 1632 |
| | | 24 | | | 1535 | 1598 | 1670 | 1750 | | | | 1541 | 1597 | 1659 |
| | | 26 | | | 1552 | 1621 | 1698 | 1785 | | | | 1558 | 1619 | 1687 |
| | | 28 | | | 1570 | 1643 | 1726 | 1820 | | | 1518 | 1576 | 1641 | 1714 |
| | | 30 | | | 1587 | 1666 | 1755 | 1855 | | | 1532 | 1593 | 1664 | 1742 |

**COLUMNS**

## AREAS AND WEIGHTS OF COLUMN RODS

| | Number of rods | Area of column rods | | | | | | Number of rods | Weight of column rods per linear foot | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Size of rods | | | | | | | Size of rods | | | | | |
| | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ |
| Square rods | 4 | 1.56 | 2.25 | 3.06 | 4.00 | 5.06 | 6.25 | 4 | 5.313 | 7.650 | 10.41 | 13.60 | 17.21 | 21.25 |
| | 6 | 2.34 | 3.38 | 4.59 | 6.00 | 7.59 | 9.38 | 6 | 7.969 | 11.48 | 15.62 | 20.40 | 25.82 | 31.88 |
| | 8 | 3.13 | 4.50 | 6.12 | 8.00 | 10.1 | 12.5 | 8 | 10.63 | 15.30 | 20.82 | 27.20 | 34.42 | 42.50 |
| | 10 | 3.91 | 5.63 | 7.66 | 10.0 | 12.7 | 15.6 | 10 | 13.28 | 19.13 | 26.03 | 34.00 | 43.03 | 53.13 |
| | 12 | 4.69 | 6.75 | 9.19 | 12.0 | 15.2 | 18.8 | 12 | 15.94 | 22.95 | 31.24 | 40.80 | 51.64 | 63.75 |
| | 14 | 5.47 | 7.88 | 10.7 | 14.0 | 17.7 | 21.9 | 14 | 18.59 | 26.78 | 36.44 | 47.60 | 60.24 | 74.28 |
| | 16 | 6.25 | 9.00 | 12.2 | 16.0 | 20.2 | 25.0 | 16 | 21.25 | 30.60 | 41.65 | 54.40 | 68.85 | 85.00 |
| | 18 | 7.03 | 10.1 | 13.8 | 18.0 | 22.8 | 28.1 | 18 | 23.91 | 34.43 | 46.85 | 61.20 | 77.45 | 95.63 |
| | 20 | 7.81 | 11.3 | 15.3 | 20.0 | 25.3 | 31.3 | 20 | 26.56 | 38.25 | 52.06 | 68.00 | 86.06 | 106.3 |
| | 22 | 8.59 | 12.4 | 16.8 | 22.0 | 27.8 | 34.4 | 22 | 29.22 | 42.08 | 57.27 | 74.80 | 94.67 | 116.9 |
| | 24 | 9.38 | 13.5 | 18.4 | 24.0 | 30.4 | 37.5 | 24 | 31.88 | 45.90 | 62.47 | 81.60 | 103.3 | 127.5 |
| | 26 | 10.2 | 14.6 | 19.9 | 26.0 | 32.9 | 40.6 | 26 | 34.53 | 49.73 | 67.68 | 88.40 | 111.9 | 138.1 |
| | 28 | 10.9 | 15.8 | 21.4 | 28.0 | 35.4 | 43.8 | 28 | 37.19 | 53.55 | 72.89 | 95.20 | 120.5 | 148.8 |
| | 30 | 11.7 | 16.9 | 23.0 | 30.0 | 38.0 | 46.9 | 30 | 39.84 | 57.38 | 78.09 | 102.0 | 129.1 | 159.4 |
| Round rods | 4 | 1.23 | 1.77 | 2.41 | 3.14 | 3.98 | 4.91 | 4 | 4.172 | 6.008 | 8.178 | 10.68 | 13.52 | 16.69 |
| | 6 | 1.84 | 2.65 | 3.61 | 4.71 | 5.96 | 7.36 | 6 | 6.259 | 9.013 | 12.27 | 16.02 | 20.28 | 25.03 |
| | 8 | 2.45 | 3.53 | 4.81 | 6.28 | 7.95 | 9.82 | 8 | 8.345 | 12.02 | 16.36 | 21.36 | 27.04 | 33.37 |
| | 10 | 3.07 | 4.42 | 6.01 | 7.85 | 9.94 | 12.3 | 10 | 10.43 | 15.02 | 20.44 | 26.70 | 33.80 | 41.72 |
| | 12 | 3.68 | 5.30 | 7.22 | 9.42 | 11.9 | 14.7 | 12 | 12.52 | 18.03 | 24.53 | 32.04 | 40.56 | 50.06 |
| | 14 | 4.30 | 6.19 | 8.42 | 11.0 | 13.9 | 17.2 | 14 | 14.60 | 21.03 | 28.62 | 37.39 | 47.31 | 58.41 |
| | 16 | 4.91 | 7.07 | 9.62 | 12.6 | 15.9 | 19.6 | 16 | 16.69 | 24.03 | 32.71 | 42.73 | 54.07 | 66.75 |
| | 18 | 5.52 | 7.95 | 10.8 | 14.1 | 17.9 | 22.1 | 18 | 18.78 | 27.04 | 36.80 | 48.07 | 60.83 | 75.09 |
| | 20 | 6.14 | 8.84 | 12.0 | 15.7 | 19.9 | 24.5 | 20 | 20.86 | 30.04 | 40.89 | 53.41 | 67.59 | 83.44 |
| | 22 | 6.75 | 9.72 | 13.2 | 17.3 | 21.9 | 27.0 | 22 | 22.95 | 33.05 | 44.98 | 58.75 | 74.35 | 91.78 |
| | 24 | 7.36 | 10.6 | 14.4 | 18.8 | 23.9 | 29.4 | 24 | 25.03 | 36.05 | 49.07 | 64.09 | 81.11 | 100.1 |
| | 26 | 7.98 | 11.5 | 15.6 | 20.4 | 25.8 | 31.9 | 26 | 27.12 | 39.06 | 53.15 | 69.43 | 87.87 | 108.5 |
| | 28 | 8.59 | 12.4 | 16.8 | 22.0 | 27.8 | 34.4 | 28 | 29.21 | 42.06 | 57.24 | 74.77 | 94.63 | 116.8 |
| | 30 | 9.20 | 13.3 | 18.0 | 23.6 | 29.8 | 36.8 | 30 | 31.29 | 45.06 | 61.33 | 80.11 | 110.4 | 125.2 |

# AREA, VOLUME, WEIGHT AND PERIMETER OF SQUARE, ROUND AND OCTAGONAL COLUMNS

| Diameter of column | Square columns | | | | Round columns | | | | Octagonal columns | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area (sq. in.) | Volume (c. f. per ft.) | Weight (lb. per ft.) | Perimeter (ft.) | Area (sq. in.) | Volume (c. f. per ft.) | Weight (lb. per ft.) | Perimeter (ft.) | Volume (c. f. per ft.) | Weight (lb. per ft.) | Perimeter (ft.) |
| 10 | 100 | 0.69 | 104 | 3.3 | 78.54 | 0.55 | 82 | 2.62 | 0.58 | 86 | 2.76 |
| 11 | 121 | 0.84 | 126 | 3.7 | 95.03 | 0.66 | 99 | 2.88 | 0.70 | 104 | 3.14 |
| 12 | 144 | 1.00 | 150 | 4.0 | 113.1 | 0.79 | 118 | 3.14 | 0.83 | 124 | 3.31 |
| 13 | 169 | 1.17 | 175 | 4.3 | 132.7 | 0.92 | 138 | 3.40 | 0.97 | 146 | 3.57 |
| 14 | 196 | 1.36 | 204 | 4.7 | 153.9 | 1.07 | 160 | 3.66 | 1.13 | 169 | 3.87 |
| 15 | 225 | 1.56 | 234 | 5.0 | 176.7 | 1.23 | 184 | 3.93 | 1.29 | 194 | 4.14 |
| 16 | 256 | 1.78 | 267 | 5.3 | 201.1 | 1.40 | 209 | 4.18 | 1.47 | 221 | 4.42 |
| 17 | 289 | 2.01 | 302 | 5.7 | 227.0 | 1.58 | 236 | 4.45 | 1.66 | 249 | 4.70 |
| 18 | 324 | 2.25 | 338 | 6.0 | 254.5 | 1.77 | 265 | 4.71 | 1.86 | 280 | 4.97 |
| 19 | 361 | 2.51 | 377 | 6.3 | 283.5 | 1.97 | 295 | 4.97 | 2.08 | 312 | 5.25 |
| 20 | 400 | 2.78 | 417 | 6.7 | 314.2 | 2.18 | 327 | 5.23 | 2.30 | 345 | 5.52 |
| 21 | 441 | 3.06 | 459 | 7.0 | 346.4 | 2.41 | 361 | 5.50 | 2.54 | 381 | 5.80 |
| 22 | 484 | 3.36 | 504 | 7.3 | 380.1 | 2.64 | 396 | 5.76 | 2.78 | 418 | 6.08 |
| 23 | 529 | 3.68 | 552 | 7.7 | 415.5 | 2.89 | 433 | 6.02 | 3.04 | 457 | 6.35 |
| 24 | 576 | 4.00 | 600 | 8.0 | 452.4 | 3.14 | 471 | 6.28 | 3.31 | 497 | 6.63 |
| 25 | 625 | 4.34 | 651 | 8.3 | 490.9 | 3.41 | 511 | 6.55 | 3.60 | 539 | 6.90 |
| 26 | 676 | 4.69 | 704 | 8.7 | 530.9 | 3.69 | 553 | 6.81 | 3.89 | 583 | 7.18 |
| 27 | 729 | 5.06 | 758 | 9.0 | 572.6 | 3.98 | 596 | 7.07 | 4.19 | 629 | 7.45 |
| 28 | 784 | 5.44 | 816 | 9.3 | 615.8 | 4.28 | 641 | 7.33 | 4.51 | 677 | 7.73 |
| 29 | 841 | 5.84 | 877 | 9.7 | 660.5 | 4.59 | 688 | 7.58 | 4.84 | 726 | 8.01 |
| 30 | 900 | 6.25 | 938 | 10.0 | 706.9 | 4.91 | 736 | 7.86 | 5.18 | 777 | 8.29 |
| 31 | 961 | 6.67 | 1000 | 10.3 | 754.8 | 5.24 | 786 | 8.12 | 5.53 | 829 | 6.56 |
| 32 | 1024 | 7.12 | 1067 | 10.7 | 804.2 | 5.58 | 838 | 8.38 | 5.89 | 884 | 8.84 |
| 33 | 1089 | 7.56 | 1134 | 11.0 | 855.3 | 5.94 | 891 | 8.64 | 6.27 | 940 | 9.11 |
| 34 | 1156 | 8.02 | 1203 | 11.3 | 907.9 | 6.30 | 946 | 8.89 | 6.55 | 983 | 9.39 |
| 35 | 1225 | 8.50 | 1275 | 11.7 | 962.1 | 6.68 | 1002 | 9.16 | 7.05 | 1057 | 9.67 |
| 36 | 1296 | 9.00 | 1350 | 12.0 | 1018 | 7.07 | 1060 | 9.42 | 7.46 | 1118 | 9.94 |
| 37 | 1369 | 9.50 | 1425 | 12.3 | 1075 | 7.47 | 1120 | 9.68 | 7.88 | 1181 | 10.22 |
| 38 | 1444 | 10.03 | 1505 | 12.7 | 1134 | 7.88 | 1181 | 9.95 | 8.31 | 1246 | 10.50 |
| 39 | 1521 | 10.57 | 1586 | 13.0 | 1195 | 8.30 | 1244 | 10.21 | 8.75 | 1313 | 10.78 |
| 40 | 1600 | 11.11 | 1666 | 13.3 | 1257 | 8.73 | 1309 | 10.47 | 9.21 | 1381 | 11.05 |
| 41 | 1681 | 11.68 | 1753 | 13.7 | 1320 | 9.17 | 1375 | 10.72 | 9.67 | 1451 | 11.33 |
| 42 | 1764 | 12.25 | 1839 | 14.0 | 1385 | 9.62 | 1443 | 10.99 | 10.15 | 1522 | 11.60 |
| 43 | 1849 | 12.84 | 1926 | 14.3 | 1452 | 10.08 | 1513 | 11.26 | 10.64 | 1596 | 11.88 |
| 44 | 1936 | 13.45 | 2020 | 14.7 | 1520 | 10.56 | 1584 | 11.52 | 11.14 | 1671 | 12.17 |
| 45 | 2025 | 14.06 | 2110 | 15.0 | 1590 | 11.04 | 1657 | 11.79 | 11.65 | 1748 | 12.43 |
| 46 | 2116 | 14.69 | 2202 | 15.3 | 1662 | 11.54 | 1731 | 12.04 | 12.17 | 1826 | 12.70 |
| 47 | 2209 | 15.34 | 2300 | 15.7 | 1735 | 12.05 | 1807 | 12.31 | 12.71 | 1906 | 12.98 |
| 48 | 2304 | 16.01 | 2400 | 16.0 | 1810 | 12.57 | 1885 | 12.57 | 13.26 | 1988 | 13.26 |
| 49 | 2401 | 16.68 | 2502 | 16.3 | 1886 | 13.10 | 1964 | 12.83 | 13.81 | 2072 | 13.53 |
| 50 | 2500 | 17.36 | 2604 | 16.7 | 1964 | 13.64 | 2045 | 13.10 | 14.38 | 2158 | 13.81 |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire...... | | #6 | #5 | #4 | #3 | ¼″ | #2 | #1 | #0 | 5⁄16″ | #2/0 | #3/0 | ⅜″ | #4/0 | #5/0 | 7⁄16″ | #6/0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches). | | 0.1920 | 0.2070 | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3938 | 0.4305 | 0.4375 | 0.4615 |
| Area (sq. in.)...... | | 0.0290 | 0.0337 | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 8 | 1¼ | **1.160** | **1.348** | **1.596** | **1.863** | **1.963** | **2.164** | | | | | | | | | | |
| | 1½ | **0.966** | **1.122** | **1.329** | **1.552** | **1.637** | **1.802** | **2.098** | | | | | | | | | |
| | 1¾ | **0.828** | **0.963** | **1.139** | **1.331** | **1.402** | **1.546** | **1.798** | **2.109** | **2.193** | | | | | | | |
| | **2** | **0.725** | **0.843** | **0.998** | **1.164** | **1.227** | **1.352** | **1.572** | **1.845** | **1.917** | **2.150** | | | | | | |
| | 2¼ | **0.644** | **0.748** | **0.887** | **1.036** | **1.090** | **1.201** | **1.393** | **1.640** | **1.704** | **1.910** | **2.293** | | | | | |
| | 2½ | **0.580** | **0.674** | **0.798** | **0.932** | **0.982** | **1.081** | **1.258** | **1.477** | **1.534** | **1.720** | **2.065** | | | | | |
| | 2¾ | **0.527** | **0.613** | **0.725** | **0.847** | **0.892** | **0.983** | **1.144** | **1.343** | **1.394** | **1.562** | **1.878** | **2.009** | | | | |
| | **3** | **0.483** | **0.562** | **0.665** | **0.777** | **0.819** | **0.902** | **1.048** | **1.230** | **1.278** | **1.432** | **1.721** | **1.842** | **2.030** | | | |
| | | | | | | | | | 1 % | | | | | | 2 % | | |
| | 1¼ | 1.99 | 2.31 | 2.73 | 3.19 | 3.36 | 3.70 | | | | | | | | | | |
| | 1½ | 1.66 | 1.93 | 2.28 | 2.66 | 2.89 | 3.09 | 3.59 | | | | | | | | | |
| | 1¾ | 1.42 | 1.65 | 1.95 | 2.28 | 2.40 | 2.65 | 3.08 | 3.61 | 3.76 | | | | | | | |
| | 2 | 1.24 | 1.44 | 1.71 | 2.00 | 2.10 | 2.32 | 2.69 | 3.16 | 3.29 | 3.68 | | | | | | |
| | 2¼ | 1.10 | 1.28 | 1.52 | 1.77 | 1.87 | 2.06 | 2.39 | 2.81 | 2.92 | 3.27 | 3.93 | | | | | |
| | 2½ | 0.99 | 1.15 | 1.37 | 1.60 | 1.68 | 1.85 | 2.15 | 2.53 | 2.63 | 2.95 | 3.54 | | | | | |
| | 2¾ | 0.90 | 1.05 | 1.24 | 1.45 | 1.53 | 1.68 | 1.96 | 2.30 | 2.39 | 2.68 | 3.22 | 3.44 | | | | |
| | 3 | 0.83 | 0.96 | 1.14 | 1.33 | 1.40 | 1.54 | 1.79 | 2.11 | 2.19 | 2.45 | 2.94 | 3.15 | 3.47 | | | |
| 9 | 1¼ | **1.030** | **1.197** | **1.417** | **1.657** | **1.748** | **1.924** | **2.235** | | | | | | | | | |
| | 1½ | **0.858** | **0.998** | **1.180** | **1.380** | **1.456** | **1.602** | **1.861** | **2.185** | **2.275** | | | | | | | |
| | 1¾ | **0.736** | **0.856** | **1.013** | **1.184** | **1.247** | **1.374** | **1.597** | **1.873** | **1.949** | **2.182** | | | | | | |
| | **2** | **0.644** | **0.748** | **0.836** | **1.034** | **1.090** | **1.202** | **1.396** | **1.640** | **1.704** | **1.910** | **2.296** | | | | | |
| | 2¼ | **0.573** | **0.666** | **0.788** | **0.921** | **0.970** | **1.068** | **1.242** | **1.459** | **1.513** | **1.700** | **2.040** | **2.182** | | | | |
| | 2½ | **0.516** | **0.599** | **0.709** | **0.828** | **0.873** | **0.962** | **1.119** | **1.313** | **1.363** | **1.529** | **1.837** | **1.964** | **2.164** | | | |
| | 2¾ | **0.469** | **0.545** | **0.645** | **0.753** | **0.794** | **0.875** | **1.017** | **1.193** | **1.240** | **1.390** | **1.669** | **1.785** | **1.969** | **2.352** | | |
| | **3** | ...... | **0.499** | **0.591** | **0.690** | **0.727** | **0.801** | **0.932** | **1.093** | **1.136** | **1.273** | **1.529** | **1.637** | **1.803** | **2.156** | | |
| | 1¼ | 2.23 | 2.60 | 3.07 | 3.59 | 3.78 | 4.17 | 4.84 | | | | | | | | | |
| | 1½ | 1.86 | 2.16 | 2.56 | 2.99 | 3.15 | 3.47 | 4.04 | 4.74 | 4.92 | | | | | | | |
| | 1¾ | 1.60 | 1.85 | 2.20 | 2.56 | 2.70 | 2.98 | 3.46 | 4.06 | 4.22 | 4.73 | | | | | | |
| | 2 | 1.40 | 1.62 | 1.92 | 2.24 | 2.36 | 2.60 | 3.03 | 3.55 | 3.69 | 4.14 | 4.97 | | | | | |
| | 2¼ | 1.24 | 1.44 | 1.71 | 1.99 | 2.10 | 2.31 | 2.69 | 3.16 | 3.28 | 3.68 | 4.42 | 4.73 | | | | |
| | 2½ | 1.12 | 1.30 | 1.54 | 1.79 | 1.89 | 2.08 | 2.42 | 2.84 | 2.95 | 3.31 | 3.97 | 4.26 | 4.69 | | | |
| | 2¾ | 1.01 | 1.18 | 1.40 | 1.63 | 1.72 | 1.89 | 2.20 | 2.58 | 2.68 | 3.01 | 3.61 | 3.87 | 4.26 | 5.09 | | |
| | 3 | ...... | 1.08 | 1.28 | 1.50 | 1.58 | 1.74 | 2.02 | 2.37 | 2.46 | 2.76 | 3.31 | 3.55 | 3.91 | 4.68 | | |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1¼ | **0.928** | **1.079** | **1.276** | **1.490** | **1.570** | **1.730** | **2.011** | **2.360** | | | | | | | | |
| | 1½ | **0.774** | **0.899** | **1.063** | **1.242** | **1.310** | **1.442** | **1.677** | **1.969** | **2.047** | **2.292** | | | | | | |
| | 1¾ | **0.663** | **0.770** | **0.912** | **1.064** | **1.121** | **1.236** | **1.437** | **1.687** | **1.753** | **1.965** | **2.360** | | | | | |
| | 2 | **0.580** | **0.674** | **0.798** | **0.931** | **0.981** | **1.082** | **1.258** | **1.476** | **1.534** | **1.720** | **2.064** | **2.210** | | | | |
| | 2¼ | **0.515** | **0.599** | **0.709** | **0.828** | **0.873** | **0.962** | **1.118** | **1.313** | **1.364** | **1.529** | **1.836** | **1.963** | **2.162** | | | |
| | 2½ | **0.464** | **0.539** | **0.638** | **0.745** | **0.785** | **0.865** | **1.006** | **1.181** | **1.226** | **1.376** | **1.650** | **1.768** | **1.948** | **2.329** | | |
| | 2¾ | ...... | **0.490** | **0.580** | **0.678** | **0.715** | **0.787** | **0.915** | **1.173** | **1.115** | **1.251** | **1.501** | **1.609** | **1.770** | **2.118** | | |
| | 3 | ...... | **0.449** | **0.532** | **0.621** | **0.655** | **0.721** | **0.838** | **0.985** | **1.021** | **1.146** | **1.376** | **1.473** | **1.622** | **1.940** | **2.004** | |
| | 1¼ | 2.48 | 2.89 | 3.42 | 3.99 | 4.20 | 4.63 | 5.38 | 6.31 | | | | | | | | |
| | 1½ | 2.07 | 2.40 | 2.85 | 3.33 | 3.50 | 3.86 | 4.48 | 5.26 | 5.47 | 6.14 | | | | | | |
| | 1¾ | 1.77 | 2.06 | 2.44 | 2.85 | 3.00 | 3.31 | 3.84 | 4.52 | 4.69 | 5.26 | 6.31 | | | | | |
| | 2 | 1.55 | 1.80 | 2.13 | 2.49 | 2.63 | 2.89 | 3.36 | 3.95 | 4.10 | 4.60 | 5.52 | 5.91 | | | | |
| | 2¼ | 1.38 | 1.60 | 1.90 | 2.22 | 2.33 | 2.57 | 2.99 | 3.51 | 3.65 | 4.09 | 4.91 | 5.25 | 5.79 | | | |
| | 2½ | 1.24 | 1.44 | 1.71 | 2.00 | 2.11 | 2.32 | 2.69 | 3.16 | 3.29 | 3.68 | 4.42 | 4.73 | 5.21 | 6.23 | | |
| | 2¾ | ..... | 1.31 | 1.55 | 1.81 | 1.91 | 2.11 | 2.45 | 2.87 | 2.98 | 3.35 | 4.02 | 4.30 | 4.74 | 5.66 | | |
| | 3 | ..... | 1.20 | 1.42 | 1.66 | 1.75 | 1.93 | 2.24 | 2.63 | 2.73 | 3.07 | 3.68 | 3.94 | 4.34 | 5.19 | 5.36 | |
| 11 | 1¼ | **0.844** | **0.981** | **1.160** | **1.355** | **1.428** | **1.573** | **1.829** | **2.144** | **2.232** | | | | | | | |
| | 1½ | **0.703** | **0.817** | **0.967** | **1.129** | **1.190** | **1.312** | **1.525** | **1.789** | **1.860** | **2.083** | | | | | | |
| | 1¾ | **0.603** | **0.700** | **0.829** | **0.968** | **1.019** | **1.123** | **1.306** | **1.533** | **1.592** | **1.786** | **2.144** | | | | | |
| | 2 | **0.527** | **0.613** | **0.725** | **0.847** | **0.893** | **0.983** | **1.143** | **1.341** | **1.393** | **1.562** | **1.877** | **2.009** | **2.216** | | | |
| | 2¼ | **0.468** | **0.545** | **0.645** | **0.753** | **0.794** | **0.875** | **1.017** | **1.192** | **1.240** | **1.390** | **1.669** | **1.786** | **1.969** | **2.352** | | |
| | 2½ | ..... | **0.490** | **0.580** | **0.678** | **0.714** | **0.787** | **0.915** | **1.072** | **1.115** | **1.251** | **1.501** | **1.609** | **1.771** | **2.119** | **2.188** | |
| | 2¾ | .... | **0.446** | **0.528** | **0.616** | **0.649** | **0.715** | **0.832** | **0.976** | **1.013** | **1.136** | **1.365** | **1.461** | **1.610** | **1.926** | **1.989** | **2.212** |
| | 3 | ...... | ...... | **0.483** | **0.564** | **0.595** | **0.655** | **0.762** | **0.895** | **0.929** | **1.041** | **1.250** | **1.339** | **1.475** | **1.762** | **1.821** | **2.028** |
| | 1¼ | 2.73 | 3.18 | 3.76 | 4.38 | 4.63 | 5.10 | 5.92 | 6.95 | 7.23 | | | | | | | |
| | 1½ | 2.28 | 2.64 | 3.13 | 3.66 | 3.85 | 4.25 | 4.94 | 5.79 | 6.02 | 6.75 | | | | | | |
| | 1¾ | 1.95 | 2.27 | 2.68 | 3.13 | 3.30 | 3.64 | 4.23 | 4.97 | 5.16 | 5.78 | 6.95 | | | | | |
| | 2 | 1.71 | 1.98 | 2.35 | 2.74 | 2.89 | 3.18 | 3.70 | 4.34 | 4.51 | 5.06 | 6.08 | 6.50 | 7.16 | | | |
| | 2¼ | 1.52 | 1.76 | 2.09 | 2.44 | 2.57 | 2.83 | 3.29 | 3.86 | 4.01 | 4.50 | 5.40 | 5.78 | 6.37 | 7.62 | | |
| | 2½ | ...... | 1.59 | 1.88 | 2.19 | 2.31 | 2.55 | 2.96 | 3.47 | 3.61 | 4.05 | 4.87 | 5.20 | 5.73 | 6.85 | 7.08 | |
| | 2¾ | ...... | 1.44 | 1.71 | 2.00 | 2.10 | 2.32 | 2.69 | 3.16 | 3.28 | 3.68 | 4.42 | 4.73 | 5.21 | 6.23 | 6.44 | 7.17 |
| | 3 | ...... | ...... | 1.57 | 1.83 | 1.93 | 2.12 | 2.46 | 2,89 | 3.01 | 3.37 | 4.05 | 4.33 | 4.78 | 5.71 | 5.90 | 6.56 |
| 12 | 1¼ | ...... | ...... | **1.062** | **1.241** | **1.309** | **1.443** | **1.677** | **1.968** | **2.045** | **2.293** | | | | | | |
| | 1½ | ...... | ...... | **0.887** | **1.036** | **1.091** | **1.200** | **1.398** | **1.640** | **1.704** | **1.911** | **2.293** | | | | | |
| | 1¾ | ...... | ...... | **0.760** | **0.888** | **0.935** | **1.030** | **1.199** | **1.406** | **1.461** | **1.638** | **1.966** | **2.105** | | | | |
| | 2 | ...... | ...... | **0.665** | **0.776** | **0.818** | **0.902** | **1.049** | **1.229** | **1.279** | **1.433** | **1.720** | **1.842** | **2.030** | | | |
| | 2¼ | ...... | ...... | **0.592** | **0.689** | **0.727** | **0.802** | **0.932** | **1.092** | **1.137** | **1.274** | **1.529** | **1.637** | **1.804** | **2.157** | | |
| | 2½ | ...... | ...... | **0.533** | **0.622** | **0.655** | **0.722** | **0.849** | **0.985** | **1.023** | **1.149** | **1.376** | **1.475** | **1.624** | **1.941** | **2.004** | |
| | 2¾ | ...... | ...... | **0.484** | **0.565** | **0.594** | **0.656** | **0.762** | **0.893** | **0.929** | **1.042** | **1.251** | **1.340** | **1.476** | **1.765** | **1.822** | **2.028** |
| | 3 | ...... | ...... | **0.443** | **0.517** | **0.546** | **0.602** | **0.698** | **0.820** | **0.852** | **0.956** | **1.147** | **1.229** | **1.353** | **1.617** | **1.670** | **1.858** |

COLUMNS

TABLE 46

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire....... | | #4 | #3 | ¼″ | #2 | #1 | #0 | 5⁄16″ | #2/0 | #3/0 | ⅜″ | #4/0 | #5/0 | 7⁄16″ | #6/0 | #7/0 | ½″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches). | | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3938 | 0.4305 | 0.4375 | 0.4615 | 0.4900 | 0.5000 |
| Area (sq. in.)..... | | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 | 0.1886 | 0.1964 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 12 | 1¼ | 4.10 | 4.79 | 5.05 | 5.56 | 6.46 | 7.59 | 7.89 | 8.84 | | | | | | | | |
| | 1½ | 3.42 | 3.99 | 4.20 | 4.64 | 5.39 | 6.32 | 6.57 | 7.36 | 8.84 | | | | | | | |
| | 1¾ | 2.93 | 3.42 | 3.61 | 3.97 | 4.62 | 5.42 | 5.64 | 6.31 | 7.58 | 8.11 | | | | | | |
| | 2 | 2.56 | 3.00 | 3.15 | 3.47 | 4.04 | 4.74 | 4.93 | 5.52 | 6.63 | 7.10 | 7.81 | | | | | |
| | 2¼ | 2.28 | 2.66 | 2.81 | 3.09 | 3.59 | 4.21 | 4.38 | 4.91 | 5.90 | 6.31 | 6.95 | 8.31 | | | | |
| | 2½ | 2.05 | 2.40 | 2.52 | 2.78 | 3.23 | 3.79 | 3.94 | 4.42 | 5.31 | 5.67 | 6.25 | 7.48 | 7.72 | | | |
| | 2¾ | 1.86 | 2.18 | 2.29 | 2.53 | 2.94 | 3.44 | 3.58 | 4.02 | 4.82 | 5.16 | 5.69 | 6.80 | 7.02 | 7.81 | | |
| | 3 | 1.71 | 1.99 | 2.11 | 2.32 | 2.69 | 3.16 | 3.28 | 3.68 | 4.42 | 4.74 | 5.21 | 6.23 | 6.44 | 7.17 | 8.07 | |
| 13 | **1½** | **0.818** | **0.955** | **1.006** | **1.108** | **1.290** | **1.514** | **1.573** | **1.764** | **2.117** | **2.267** | | | | | | |
| | **1¾** | **0.702** | **0.819** | **0.863** | **0.951** | **1.104** | **1.297** | **1.349** | **1.512** | **1.815** | **1.943** | **2.142** | | | | | |
| | **2** | **0.614** | **0.717** | **0.755** | **0.832** | **0.968** | **1.136** | **1.180** | **1.323** | **1.588** | **1.700** | **1.874** | **2.240** | | | | |
| | **2¼** | **0.546** | **0.637** | **0.672** | **0.739** | **0.861** | **1.010** | **1.049** | **1.176** | **1.411** | **1.511** | **1.666** | **1.991** | **2.055** | | | |
| | **2½** | **0.491** | **0.573** | **0.605** | **0.666** | **0.774** | **0.908** | **0.944** | **1.059** | **1.270** | **1.360** | **1.499** | **1.792** | **1.850** | **2.059** | | |
| | **2¾** | **0.446** | **0.521** | **0.549** | **0.606** | **0.704** | **0.827** | **0.859** | **0.963** | **1.156** | **1.239** | **1.363** | **1.629** | **1.682** | **1.872** | **2.110** | |
| | **3** | ...... | **0.478** | **0.503** | **0.555** | **0.645** | **0.757** | **0.787** | **0.882** | **1.059** | **1.133** | **1.249** | **1.493** | **1.541** | **1.716** | **1.934** | **2.014** |
| | 1½ | 3.70 | 4.32 | 4.55 | 5.02 | 5.83 | 6.84 | 7.11 | 7.98 | 9.58 | 10.24 | | | | | | |
| | 1¾ | 3.17 | 3.71 | 3.90 | 4.30 | 5.00 | 5.86 | 6.10 | 6.84 | 8.20 | 8.78 | 9.67 | | | | | |
| | 2 | 2.78 | 3.24 | 3.42 | 3.76 | 4.37 | 5.13 | 5.34 | 5.98 | 7.18 | 7.69 | 8.46 | 10.11 | | | | |
| | 2¼ | 2.46 | 2.88 | 3.04 | 3.34 | 3.89 | 4.56 | 4.74 | 5.32 | 6.38 | 6.84 | 7.52 | 9.00 | 9.30 | | | |
| | 2½ | 2.22 | 2.59 | 2.73 | 3.01 | 3.50 | 4.11 | 4.27 | 4.78 | 5.74 | 6.14 | 6.76 | 8.09 | 8.36 | 9.30 | | |
| | 2¾ | 2.02 | 2.36 | 2.48 | 2.74 | 3.18 | 3.74 | 3.88 | 4.35 | 5.22 | 5.59 | 6.15 | 7.36 | 7.60 | 8.46 | 9.54 | |
| | 3 | ...... | 2.16 | 2.28 | 2.50 | 2.92 | 3.42 | 3.56 | 3.98 | 4.79 | 5.12 | 5.64 | 6.74 | 6.97 | 7.76 | 8.74 | 9.11 |
| 14 | **1½** | **0.760** | **0.888** | **0.934** | **1.030** | **1.199** | **1.406** | **1.461** | **1.638** | **1.961** | **2.105** | **2.320** | | | | | |
| | **1¾** | **0.651** | **0.761** | **0.801** | **0.883** | **1.027** | **1.204** | **1.252** | **1.404** | **1.685** | **1.804** | **1.989** | **2.377** | | | | |
| | **2** | **0.570** | **0.665** | **0.702** | **0.773** | **0.898** | **1.054** | **1.095** | **1.228** | **1.474** | **1.579** | **1.740** | **2.080** | **2.147** | | | |
| | **2¼** | **0.506** | **0.592** | **0.623** | **0.687** | **0.798** | **0.937** | **0.974** | **1.092** | **1.311** | **1.403** | **1.547** | **1.849** | **1.909** | **2 124** | | |
| | **2½** | **0.456** | **0.532** | **0.561** | **0.618** | **0.719** | **0.844** | **0.876** | **0.983** | **1.180** | **1.263** | **1.392** | **1.664** | **1.718** | **1.912** | **2.155** | |
| | **2¾** | ...... | **0.484** | **0.510** | **0.562** | **0.654** | **0.766** | **0.797** | **0.894** | **1.072** | **1.149** | **1.265** | **1.513** | **1.562** | **1.738** | **1.960** | **2.041** |
| | **3** | ...... | ...... | **0.467** | **0.515** | **0.599** | **0.703** | **0.731** | **0.819** | **0.983** | **1.052** | **1.159** | **1.387** | **1.431** | **1.593** | **1.796** | **1.870** |

TABLE 46

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1½ | 3.98 | 4.65 | 4.90 | 5.40 | 6.28 | 7.37 | 7.66 | 8.59 | 10.31 | 11.04 | 12.17 | | | | | |
| | 1¾ | 3.42 | 3.99 | 4.20 | 4.63 | 5.38 | 6.32 | 6.56 | 7.36 | 8.85 | 9.46 | 10.41 | 12.46 | | | | |
| | 2 | 2.99 | 3.49 | 3.68 | 4.06 | 4.71 | 5.53 | 5.75 | 6.44 | 7.73 | 8.28 | 9.12 | 10.89 | 11.27 | | | |
| | 2¼ | 2.66 | 3.10 | 3.27 | 3.61 | 4.19 | 4.91 | 5.11 | 5.73 | 6.89 | 7.36 | 8.11 | 9.70 | 10.02 | 11.16 | | |
| | 2½ | 2.39 | 2.79 | 2.94 | 3.24 | 3.77 | 4.42 | 4.60 | 5.16 | 6.19 | 6.62 | 7.30 | 8.73 | 9.02 | 10.03 | 11.30 | |
| | 2¾ | ...... | 2.54 | 2.68 | 2.95 | 3.43 | 4.02 | 4.18 | 4.69 | 5.63 | 6.02 | 6.63 | 7.93 | 8.19 | 9.12 | 10.27 | 10.70 |
| | 3 | ...... | ...... | 2.45 | 2.70 | 3.14 | 3.68 | 3.83 | 4.29 | 5.16 | 5.52 | 6.08 | 7.27 | 7.51 | 8.36 | 9.42 | 9.82 |
| 15 | **1½** | **0.709** | **0.828** | **0.873** | **0.962** | **1.119** | **1.312** | **1.364** | **1.529** | **1.835** | **1.964** | **2.165** | | | | | |
| | **1¾** | **0.608** | **0.710** | **0.748** | **0.824** | **0.958** | **1.123** | **1.169** | **1.311** | **1.572** | **1.684** | **1.856** | **2.219** | | | | |
| | **2** | **0.532** | **0.622** | **0.654** | **0.722** | **0.839** | **0.984** | **1.023** | **1.147** | **1.376** | **1.473** | **1.624** | **1.941** | **2.004** | **2.231** | | |
| | **2¼** | **0.473** | **0.552** | **0.582** | **0.641** | **0.745** | **0.875** | **0.909** | **1.019** | **1.223** | **1.310** | **1.444** | **1.726** | **1.781** | **1.983** | **2.235** | |
| | **2½** | ...... | **0.497** | **0.524** | **0.577** | **0.671** | **0.787** | **0.819** | **0.917** | **1.100** | **1.179** | **1.299** | **1.553** | **1.603** | **1.785** | **2.012** | **2.095** |
| | **2¾** | ...... | ...... | **0.476** | **0.525** | **0.610** | **0.716** | **0.744** | **0.834** | **1.002** | **1.072** | **1.182** | **1.412** | **1.457** | **1.622** | **1.829** | **1.904** |
| | **3** | ...... | ...... | ...... | **0.481** | **0.559** | **0.656** | **0.682** | **0.764** | **0.917** | **0.982** | **1.082** | **1.294** | **1.336** | **1.487** | **1.676** | **1.746** |
| | 1½ | 4.27 | 4.99 | 5.25 | 5.79 | 6.72 | 7.90 | 8.21 | 9.20 | 11.06 | 11.81 | 13.01 | | | | | |
| | 1¾ | 3.66 | 4.28 | 4.50 | 4.96 | 5.76 | 6.76 | 7.04 | 7.89 | 9.48 | 10.14 | 11.18 | 13.36 | | | | |
| | 2 | 3.20 | 3.74 | 3.94 | 4.35 | 5.05 | 5.92 | 6.15 | 6.90 | 8.29 | 8.88 | 9.76 | 11.69 | 12.08 | 13.42 | | |
| | 2¼ | 2.84 | 3.32 | 3.50 | 3.86 | 4.48 | 5.26 | 5.46 | 6.14 | 7.36 | 7.88 | 8.68 | 10.38 | 10.72 | 11.94 | 13.46 | |
| | 2½ | ...... | 2.99 | 3.75 | 3.47 | 4.03 | 4.74 | 4.92 | 5.52 | 6.63 | 7.09 | 7.82 | 9.34 | 9.65 | 10.73 | 12.09 | 12.61 |
| | 2¾ | ...... | ...... | 2.86 | 3.16 | 3.66 | 4.30 | 4.48 | 5.02 | 6.03 | 6.45 | 7.10 | 8.48 | 8.78 | 9.78 | 11.00 | 11.46 |
| | 3 | ...... | ...... | ...... | 2.89 | 3.36 | 3.94 | 4.10 | 4.60 | 5.58 | 5.91 | 6.50 | 7.78 | 8.04 | 8.95 | 10.08 | 10.50 |
| 16 | **1½** | **0.665** | **0.777** | **0.818** | **0.901** | **1.049** | **1.230** | **1.279** | **1.433** | **1.720** | **1.842** | **2.030** | | | | | |
| | **1¾** | **0.570** | **0.666** | **0.701** | **0.773** | **0.898** | **1.054** | **1.097** | **1.229** | **1.474** | **1.579** | **1.740** | **2.080** | **2.147** | | | |
| | **2** | **0.499** | **0.583** | **0.614** | **0.676** | **0.786** | **0.923** | **0.959** | **1.075** | **1.290** | **1.381** | **1.522** | **1.820** | **1.879** | **2.091** | | |
| | **2¼** | **0.443** | **0.518** | **0.546** | **0.601** | **0.699** | **0.820** | **0.852** | **0.956** | **1.149** | **1.228** | **1.353** | **1.618** | **1.670** | **1.859** | **2.096** | **2.182** |
| | **2½** | ...... | **0.466** | **0.491** | **0.541** | **0.629** | **0.738** | **0.767** | **0.860** | **1.032** | **1.105** | **1.218** | **1.456** | **1.503** | **1.673** | **1.886** | **1.964** |
| | **2¾** | ...... | ...... | ...... | **0.491** | **0.572** | **0.671** | **0.697** | **0.782** | **0.940** | **1.004** | **1.107** | **1.324** | **1.366** | **1.521** | **1.715** | **1.785** |
| | **3** | ...... | ...... | ...... | **0.451** | **0.524** | **0.615** | **0.639** | **0.717** | **0.861** | **0.921** | **1.015** | **1.213** | **1.253** | **1.394** | **1.572** | **1.637** |
| | 1½ | 4.55 | 5.32 | 5.60 | 6.18 | 7.17 | 8.42 | 8.76 | 9.81 | 11.79 | 12.61 | 13.89 | | | | | |
| | 1¾ | 3.90 | 4.56 | 4.80 | 5.30 | 6.15 | 7.21 | 7.50 | 8.41 | 10.10 | 10.80 | 11.90 | 14.23 | 14.70 | | | |
| | 2 | 3.42 | 3.99 | 4.20 | 4.63 | 5.38 | 6.32 | 6.57 | 7.36 | 8.84 | 9.45 | 10.41 | 12.46 | 12.88 | 14.32 | | |
| | 2¼ | 3.03 | 3.54 | 3.74 | 4.11 | 4.79 | 5.61 | 5.84 | 6.54 | 7.86 | 8.41 | 9.26 | 11.08 | 11.44 | 12.72 | 14.33 | 14.94 |
| | 2½ | ...... | 3.18 | 3.36 | 3.70 | 4.30 | 5.04 | 5.25 | 5.88 | 7.07 | 7.56 | 8.33 | 9.96 | 10.29 | 11.46 | 12.91 | 13.46 |
| | 2¾ | ...... | ...... | ...... | 3.36 | 3.91 | 4.59 | 4.77 | 5.35 | 6.43 | 6.87 | 7.57 | 9.06 | 9.36 | 10.41 | 11.73 | 12.21 |
| | 3 | ...... | ...... | ...... | 3.09 | 3.58 | 4.21 | 4.37 | 4.90 | 5.89 | 6.30 | 6.95 | 8.30 | 8.58 | 9.55 | 10.73 | 11.20 |
| 17 | **1½** | **0.626** | **0.731** | **0.770** | **0.849** | **0.986** | **1.159** | **1.203** | **1.349** | **1.619** | **1.733** | **1.911** | **2.284** | | | | |
| | **1¾** | **0.536** | **0.627** | **0.660** | **0.728** | **0.845** | **0.992** | **1.032** | **1.157** | **1.388** | **1.486** | **1.638** | **1.958** | **2.021** | **2.250** | | |
| | **2** | **0.469** | **0.548** | **0.578** | **0.636** | **0.740** | **0.868** | **0.903** | **1.012** | **1.215** | **1.300** | **1.433** | **1.713** | **1.768** | **1.968** | **2.219** | |
| | **2¼** | ...... | **0.487** | **0.513** | **0.566** | **0.658** | **0.772** | **0.803** | **0.900** | **1.080** | **1.156** | **1.273** | **1.523** | **1.572** | **1.750** | **1.972** | **2.054** |
| | **2½** | ...... | ...... | **0.462** | **0.510** | **0.592** | **0.694** | **0.722** | **0.809** | **0.972** | **1.040** | **1.146** | **1.370** | **1.415** | **1.574** | **1.775** | **1.848** |
| | **2¾** | ...... | ...... | ...... | **0.463** | **0.538** | **0.631** | **0.656** | **0.736** | **0.884** | **0.946** | **1.041** | **1.243** | **1.286** | **1.432** | **1.614** | **1.680** |
| | **3** | ...... | ...... | ...... | ...... | **0.493** | **0.579** | **0.602** | **0.675** | **0.810** | **0.867** | **0.955** | **1.141** | **1.179** | **1.312** | **1.479** | **1.540** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire....... | | #4 | #3 | ¼" | #2 | #1 | #0 | 5/16" | #2/0 | #3/0 | ⅜" | #4/0 | #5/0 | 7/16" | #6/0 | #7/0 | ½" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches). | | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3938 | 0.4305 | 0.4375 | 0.4615 | 0.4900 | 0.5000 |
| Area (sq. in.)..... | | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 | 0.1886 | 0.1964 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 17 | 1½ | 4.84 | 5.65 | 5.95 | 6.56 | 7.62 | 8.95 | 9.30 | 10.43 | 12.53 | 13.41 | 14.78 | 17.66 | | | | |
| | 1¾ | 4.15 | 4.85 | 5.11 | 5.63 | 6.54 | 7.67 | 7.98 | 8.95 | 10.73 | 11.50 | 12.67 | 15.14 | 15.63 | 17.41 | | |
| | 2 | 3.63 | 4.24 | 4.47 | 4.93 | 5.71 | 6.71 | 6.98 | 7.82 | 9.40 | 10.05 | 11.08 | 13.23 | 13.69 | 15.22 | 17.16 | |
| | 2¼ | ...... | 3.77 | 3.97 | 4.38 | 5.08 | 5.96 | 6.20 | 6.95 | 8.35 | 8.93 | 9.84 | 11.77 | 12.15 | 13.52 | 15.23 | 15.89 |
| | 2½ | ...... | ...... | 3.57 | 3.94 | 4.57 | 5.37 | 5.58 | 6.26 | 7.51 | 8.03 | 8.85 | 10.59 | 10.94 | 12.19 | 13.71 | 14.30 |
| | 2¾ | ...... | ...... | ...... | 3.58 | 4.16 | 4.88 | 5.07 | 5.69 | 6.83 | 7.31 | 8.05 | 9.62 | 9.94 | 11.06 | 12.48 | 13.00 |
| | 3 | ...... | ...... | ...... | ...... | 3.81 | 4.47 | 4.65 | 5.21 | 6.26 | 6.70 | 7.37 | 8.82 | 9.11 | 10.14 | 11.42 | 11.91 |
| 18 | 1½ | **0.591** | **0.690** | **0.728** | **0.802** | **0.932** | **1.093** | **1.138** | **1.274** | **1.529** | **1.637** | **1.804** | **2.157** | **2.227** | | | |
| | 1¾ | **0.507** | **0.592** | **0.624** | **0.687** | **0.799** | **0.937** | **0.975** | **1.092** | **1.310** | **1.403** | **1.547** | **1.849** | **1.909** | **2.124** | | |
| | 2 | **0.443** | **0.518** | **0.546** | **0.601** | **0.699** | **0.820** | **0.853** | **0.956** | **1.148** | **1.229** | **1.353** | **1.618** | **1.670** | **1.859** | **2.096** | **2.182** |
| | 2¼ | ...... | **0.460** | **0.485** | **0.535** | **0.621** | **0.729** | **0.758** | **0.850** | **1.020** | **1.092** | **1.202** | **1.438** | **1.484** | **1.652** | **1.863** | **1.940** |
| | 2½ | ...... | ...... | ...... | **0.481** | **0.559** | **0.656** | **0.682** | **0.765** | **0.918** | **0.983** | **1.081** | **1.292** | **1.336** | **1.487** | **1.676** | **1.746** |
| | 2¾ | ...... | ...... | ...... | **0.438** | **0.508** | **0.596** | **0.620** | **0.695** | **0.835** | **0.893** | **0.983** | **1.176** | **1.214** | **1.352** | **1.524** | **1.587** |
| | 3 | ...... | ...... | ...... | ...... | **0.466** | **0.547** | **0.568** | **0.637** | **0.765** | **0.819** | **0.902** | **1.079** | **1.114** | **1.240** | **1.397** | **1.455** |
| | 1½ | 5.13 | 5.99 | 6.31 | 6.95 | 8.07 | 9.48 | 9.85 | 11.03 | 13.28 | 14.20 | 15.63 | 18.70 | 19.32 | | | |
| | 1¾ | 4.39 | 5.13 | 5.40 | 5.96 | 6.92 | 8.12 | 8.45 | 9.46 | 11.38 | 12.18 | 13.40 | 16.02 | 16.56 | 18.42 | | |
| | 2 | 3.84 | 4.49 | 4.73 | 5.21 | 6.05 | 7.10 | 7.39 | 8.28 | 9.95 | 10.64 | 11.71 | 14.01 | 14.48 | 16.11 | 18.16 | 18.91 |
| | 2¼ | ...... | 3.99 | 4.20 | 4.63 | 5.38 | 6.31 | 6.56 | 7.36 | 8.84 | 9.44 | 10.41 | 12.45 | 12.88 | 14.32 | 16.13 | 16.81 |
| | 2½ | ...... | ...... | ...... | 4.17 | 4.85 | 5.68 | 5.91 | 6.63 | 7.96 | 8.51 | 9.38 | 11.21 | 11.59 | 12.90 | 14.51 | 15.13 |
| | 2¾ | ...... | ...... | ...... | 3.79 | 4.40 | 5.17 | 5.38 | 6.03 | 7.23 | 7.74 | 8.52 | 10.19 | 10.52 | 11.72 | 13.21 | 13.77 |
| | 3 | ...... | ...... | ...... | ...... | 4.04 | 4.74 | 4.93 | 5.52 | 6.63 | 7.10 | 7.81 | 9.34 | 9.66 | 10.73 | 12.10 | 12.61 |
| 19 | 1½ | **0.560** | **0.655** | **0.689** | **0.759** | **0.883** | **1.036** | **1.077** | **1.207** | **1.448** | **1.551** | **1.709** | **2.044** | **2.109** | | | |
| | 1¾ | **0.480** | **0.561** | **0.591** | **0.651** | **0.756** | **0.888** | **0.923** | **1.034** | **1.241** | **1.329** | **1.465** | **1.752** | **1.808** | **2.013** | **2.269** | |
| | 2 | ...... | **0.490** | **0.516** | **0.569** | **0.662** | **0.777** | **0.808** | **0.905** | **1.088** | **1.163** | **1.282** | **1.533** | **1.582** | **1.761** | **1.985** | **2.067** |
| | 2¼ | ...... | ...... | **0.459** | **0.506** | **0.588** | **0.691** | **0.718** | **0.804** | **0.966** | **1.033** | **1.139** | **1.362** | **1.406** | **1.565** | **1.765** | **1.838** |
| | 2½ | ...... | ...... | ...... | **0.456** | **0.530** | **0.621** | **0.646** | **0.724** | **0.869** | **0.930** | **1.024** | **1.225** | **1.266** | **1.409** | **1.588** | **1.654** |
| | 2¾ | ...... | ...... | ...... | ...... | **0.481** | **0.565** | **0.587** | **0.658** | **0.790** | **0.847** | **0.932** | **1.113** | **1.151** | **1.281** | **1.444** | **1.504** |
| | 3 | ...... | ...... | ...... | ...... | **0.441** | **0.518** | **0.538** | **0.604** | **0.724** | **0.776** | **0.854** | **1.021** | **1.054** | **1.173** | **1.324** | **1.378** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1½ | 5.41 | 6.32 | 6.66 | 7.34 | 8.52 | 10.00 | 10.40 | 11.65 | 14.00 | 14.98 | 16.50 | 19.71 | 20.39 | | | |
| | 1¾ | 4.64 | 5.42 | 5.71 | 6.30 | 7.31 | 8.57 | 8.91 | 10.00 | 12.00 | 12.84 | 14.13 | 16.91 | 17.48 | 19.47 | 21.91 | |
| | 2 | ...... | 4.74 | 4.99 | 5.50 | 6.39 | 7.50 | 7.80 | 8.74 | 10.50 | 11.22 | 12.39 | 14.79 | 15.29 | 17.01 | 19.17 | 19.98 |
| | 2¼ | ...... | ...... | 4.44 | 4.89 | 5.68 | 6.66 | 6.94 | 7.77 | 9.34 | 9.99 | 11.00 | 13.14 | 13.59 | 15.12 | 17.04 | 17.76 |
| | 2½ | ...... | ...... | ...... | 4.40 | 5.11 | 6.00 | 6.24 | 6.99 | 8.40 | 8.99 | 9.90 | 11.83 | 12.22 | 13.61 | 15.32 | 15.99 |
| | 2¾ | ...... | ...... | ...... | ...... | 4.65 | 5.46 | 5.68 | 6.36 | 7.64 | 8.18 | 9.00 | 10.77 | 11.12 | 12.38 | 13.93 | 14.52 |
| | 3 | ...... | ...... | ...... | ...... | 4.26 | 5.00 | 5.20 | 5.83 | 7.01 | 7.49 | 8.24 | 9.86 | 10.19 | 11.33 | 12.79 | 13.32 |
| 20 | **1½** | **0.532** | **0.621** | **0.655** | **0.721** | **0.838** | **0.984** | **1.023** | **1.147** | **1.376** | **1.473** | **1.624** | **1.941** | **2.004** | **2.231** | | |
| | **1¾** | **0.456** | **0.532** | **0.561** | **0.619** | **0.719** | **0.843** | **0.877** | **0.983** | **1.180** | **1.263** | **1.392** | **1.664** | **1.718** | **1.912** | **2.155** | **2.245** |
| | **2** | ...... | **0.466** | **0.491** | **0.541** | **0.629** | **0.738** | **0.767** | **0.860** | **1.032** | **1.105** | **1.218** | **1.456** | **1.503** | **1.673** | **1.886** | **1.964** |
| | **2¼** | ...... | ...... | ...... | **0.481** | **0.559** | **0.656** | **0.682** | **0.764** | **0.918** | **0.983** | **1.081** | **1.294** | **1.336** | **1.487** | **1.676** | **1.746** |
| | **2½** | ...... | ...... | ...... | **0.433** | **0.503** | **0.590** | **0.614** | **0.688** | **0.827** | **0.884** | **0.974** | **1.163** | **1.202** | **1.338** | **1.507** | **1.571** |
| | **2¾** | ...... | ...... | ...... | ...... | **0.457** | **0.536** | **0.558** | **0.626** | **0.751** | **0.804** | **0.885** | **1.058** | **1.093** | **1.217** | **1.372** | **1.428** |
| | **3** | ...... | ...... | ...... | ...... | ...... | **0.491** | **0.511** | **0.573** | **0.688** | **0.737** | **0.812** | **0.970** | **1.002** | **1.116** | **1.257** | **1.309** |
| | 1½ | 5.70 | 6.65 | 7.01 | 7.72 | 8.97 | 10.51 | 10.94 | 12.28 | 14.73 | 15.78 | 17.39 | 20.79 | 21.46 | 23.89 | | |
| | 1¾ | 4.88 | 5.70 | 6.01 | 6.62 | 7.69 | 9.03 | 9.39 | 10.51 | 12.63 | 13.51 | 14.90 | 17.81 | 18.40 | 20.47 | 23.03 | 24.02 |
| | 2 | ...... | 4.99 | 5.26 | 5.79 | 6.72 | 7.90 | 8.21 | 9.20 | 11.06 | 11.82 | 13.02 | 15.58 | 16.10 | 17.91 | 20.18 | 21.02 |
| | 2¼ | ...... | ...... | ...... | 5.15 | 5.98 | 7.02 | 7.30 | 8.18 | 9.83 | 10.50 | 11.59 | 13.86 | 14.30 | 15.92 | 17.94 | 18.69 |
| | 2½ | ...... | ...... | ...... | 4.64 | 5.38 | 6.32 | 6.57 | 7.36 | 8.84 | 9.46 | 10.41 | 12.46 | 12.89 | 14.33 | 16.15 | 16.82 |
| | 2¾ | ...... | ...... | ...... | ...... | 4.89 | 5.75 | 5.97 | 6.70 | 8.04 | 8.60 | 9.47 | 11.33 | 11.71 | 13.02 | 14.69 | 15.30 |
| | 3 | ...... | ...... | ...... | ...... | ...... | 5.26 | 5.47 | 6.14 | 7.37 | 7.88 | 8.68 | 10.38 | 10.72 | 11.93 | 13.44 | 14.01 |
| 21 | **1½** | **0.507** | **0.592** | **0.623** | **0.687** | **0.798** | **0.937** | **0.974** | **1.091** | **1.311** | **1.403** | **1.546** | **1.849** | **1.909** | **2.124** | | |
| | **1¾** | **0.434** | **0.507** | **0.534** | **0.589** | **0.684** | **0.803** | **0.834** | **0.936** | **1.123** | **1.202** | **1.326** | **1.585** | **1.636** | **1.821** | **2.053** | **2.138** |
| | **2** | ...... | **0.444** | **0.467** | **0.515** | **0.599** | **0.702** | **0.730** | **0.819** | **0.983** | **1.051** | **1.159** | **1.387** | **1.431** | **1.593** | **1.796** | **1.870** |
| | **2¼** | ...... | ...... | ...... | **0.458** | **0.532** | **0.625** | **0.649** | **0.728** | **0.874** | **0.936** | **1.031** | **1.231** | **1.273** | **1.416** | **1.597** | **1.663** |
| | **2½** | ...... | ...... | ...... | ...... | **0.479** | **0.562** | **0.584** | **0.656** | **0.786** | **0.842** | **0.927** | **1.108** | **1.146** | **1.275** | **1.437** | **1.496** |
| | **2¾** | ...... | ...... | ...... | ...... | **0.435** | **0.511** | **0.531** | **0.596** | **0.715** | **0.765** | **0.843** | **1.008** | **1.041** | **1.159** | **1.306** | **1.360** |
| | **3** | ...... | ...... | ...... | ...... | ...... | **0.468** | **0.486** | **0.546** | **0.655** | **0.702** | **0.773** | **0.924** | **0.955** | **1.062** | **1.198** | **1.247** |
| | 1½ | 5.98 | 6.98 | 7.36 | 8.10 | 9.41 | 11.06 | 11.49 | 12.88 | 15.47 | 16.55 | 18.22 | 21.80 | 22.52 | 25.05 | | |
| | 1¾ | 5.12 | 5.98 | 6.30 | 6.95 | 8.06 | 9.47 | 9.85 | 11.03 | 13.26 | 14.19 | 15.61 | 18.69 | 19.30 | 21.48 | 24.19 | 25.21 |
| | 2 | ...... | 5.23 | 5.51 | 6.08 | 7.06 | 8.29 | 8.62 | 9.66 | 11.60 | 12.41 | 13.68 | 16.35 | 16.89 | 18.80 | 21.19 | 22.05 |
| | 2¼ | ...... | ...... | ...... | 5.40 | 6.28 | 7.37 | 7.66 | 8.59 | 10.31 | 11.03 | 12.16 | 14.54 | 15.00 | 16.70 | 18.82 | 19.60 |
| | 2½ | ...... | ...... | ...... | ...... | 5.65 | 6.63 | 6.89 | 7.72 | 9.28 | 9.92 | 10.93 | 13.09 | 13.51 | 15.03 | 16.93 | 17.64 |
| | 2¾ | ...... | ...... | ...... | ...... | 5.14 | 6.03 | 6.27 | 7.03 | 8.44 | 9.03 | 9.94 | 11.90 | 12.29 | 13.68 | 15.40 | 16.05 |
| | 3 | ...... | ...... | ...... | ...... | ...... | 5.53 | 5.75 | 6.44 | 7.74 | 8.28 | 9.11 | 10.90 | 11.27 | 12.53 | 14.12 | 14.71 |
| 22 | **1½** | **0.484** | **0.565** | **0.594** | **0.655** | **0.762** | **0.895** | **0.930** | **1.042** | **1.250** | **1.340** | **1.476** | **1.764** | **1.821** | **2.027** | **2.286** | |
| | **1¾** | ...... | **0.484** | **0.510** | **0.562** | **0.653** | **0.767** | **0.797** | **0.894** | **1.072** | **1.148** | **1.265** | **1.512** | **1.561** | **1.738** | **1.959** | **2.040** |
| | **2** | ...... | ...... | **0.446** | **0.491** | **0.572** | **0.671** | **0.698** | **0.782** | **0.939** | **1.005** | **1.107** | **1.323** | **1.366** | **1.521** | **1.714** | **1.785** |
| | **2¼** | ...... | ...... | ...... | **0.437** | **0.508** | **0.597** | **0.620** | **0.695** | **0.834** | **0.894** | **0.984** | **1.177** | **1.214** | **1.352** | **1.524** | **1.587** |
| | **2½** | ...... | ...... | ...... | ...... | **0.457** | **0.537** | **0.557** | **0.626** | **0.751** | **0.804** | **0.885** | **1.059** | **1.093** | **1.218** | **1.371** | **1.428** |
| | **2¾** | ...... | ...... | ...... | ...... | ...... | **0.487** | **0.506** | **0.568** | **0.683** | **0.731** | **0.805** | **0.962** | **0.994** | **1.107** | **1.247** | **1.299** |
| | **3** | ...... | ...... | ...... | ...... | ...... | ...... | **0.465** | **0.521** | **0.626** | **0.670** | **0.738** | **0.881** | **0.911** | **1.013** | **1.142** | **1.191** |

## COLUMN SPIRALS
## PERCENTAGE OF VOLUME OF CORE
## AND
## WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire....... | | #4 | #3 | ¼" | #2 | #1 | #0 | 5/16" | #2/0 | #3/0 | ⅜" | #4/0 | #5/0 | 7/16" | #6/0 | #7/0 | ½" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches).. | | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3938 | 0.4305 | 0.4375 | 0.4615 | 0.4900 | 0.5000 |
| Area (sq. in.)..... | | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 | 0.1886 | 0.1964 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 22 | 1½ | 6.27 | 7.31 | 7.70 | 8.50 | 9.87 | 11.58 | 12.03 | 13.50 | 16.20 | 17.34 | 19.12 | 22.85 | 23.59 | 26.26 | 29.60 | |
| | 1¾ | ...... | 6.27 | 6.61 | 7.29 | 8.46 | 9.94 | 10.32 | 11.58 | 13.90 | 14.88 | 16.38 | 19.59 | 20.22 | 22.50 | 25.37 | 26.42 |
| | 2 | ...... | ...... | 5.79 | 6.38 | 7.40 | 8.69 | 9.04 | 10.12 | 12.18 | 13.01 | 14.32 | 17.14 | 17.69 | 19.69 | 22.20 | 23.12 |
| | 2¼ | ...... | ...... | ...... | 5.66 | 6.59 | 7.73 | 8.04 | 9.00 | 10.81 | 11.58 | 12.74 | 15.23 | 15.72 | 17.50 | 19.73 | 20.55 |
| | 2½ | ...... | ...... | ...... | ...... | 5.93 | 6.96 | 7.24 | 8.10 | 9.74 | 10.41 | 11.48 | 13.71 | 14.75 | 15.75 | 17.76 | 18.49 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | 6.33 | 6.58 | 7.37 | 8.85 | 9.47 | 10.42 | 12.44 | 12.84 | 14.29 | 16.11 | 16.77 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | 6.03 | 6.76 | 8.11 | 8.69 | 9.57 | 11.41 | 11.80 | 13.13 | 14.80 | 15.41 |
| 23 | 1½ | **0.463** | **0.540** | **0.569** | **0.627** | **0.729** | **0.855** | **0.889** | **0.997** | **1.198** | **1.281** | **1.412** | **1.688** | **1.743** | **1.940** | **2.187** | **2.277** |
| | 1¾ | ...... | **0.463** | **0.488** | **0.537** | **0.625** | **0.734** | **0.762** | **0.854** | **1.025** | **1.098** | **1.210** | **1.447** | **1.494** | **1.663** | **1.874** | **1.952** |
| | 2 | ...... | ...... | ...... | **0.471** | **0.547** | **0.642** | **0.667** | **0.748** | **0.898** | **0.961** | **1.060** | **1.266** | **1.307** | **1.455** | **1.640** | **1.708** |
| | 2¼ | ...... | ...... | ...... | ...... | **0.486** | **0.570** | **0.593** | **0.665** | **0.798** | **0.854** | **0.941** | **1.124** | **1.161** | **1.293** | **1.458** | **1.518** |
| | 2½ | ...... | ...... | ...... | ...... | **0.437** | **0.513** | **0.534** | **0.598** | **0.718** | **0.769** | **0.847** | **1.011** | **1.046** | **1.164** | **1.312** | **1.366** |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | **0.467** | **0.485** | **0.544** | **0.654** | **0.700** | **0.770** | **0.920** | **0.952** | **1.059** | **1.193** | **1.243** |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.499** | **0.599** | **0.641** | **0.705** | **0.844** | **0.872** | **0.970** | **1.092** | **1.140** |
| | 1½ | 6.55 | 7.65 | 8.05 | 8.88 | 10.31 | 12.10 | 12.59 | 14.10 | 16.93 | 18.13 | 19.98 | 23.89 | 24.66 | 27.45 | 30.94 | 32.22 |
| | 1¾ | ...... | 6.55 | 6.90 | 7.60 | 8.84 | 10.38 | 10.78 | 12.09 | 14.51 | 15.52 | 17.13 | 20.48 | 21.14 | 23.53 | 26.52 | 27.62 |
| | 2 | ...... | ...... | ...... | 6.65 | 7.73 | 9.07 | 9.44 | 10.57 | 12.70 | 13.59 | 14.98 | 17.92 | 18.49 | 20.59 | 23.21 | 24.17 |
| | 2¼ | ...... | ...... | ...... | ...... | 6.88 | 8.07 | 8.39 | 9.40 | 11.29 | 12.09 | 13.32 | 15.92 | 16.44 | 18.30 | 20.63 | 21.48 |
| | 2½ | ...... | ...... | ...... | ...... | 6.19 | 7.26 | 7.55 | 8.46 | 10.17 | 10.88 | 11.99 | 14.33 | 14.80 | 16.47 | 18.57 | 19.33 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | 6.60 | 6.86 | 7.69 | 9.24 | 9.88 | 10.90 | 13.03 | 13.45 | 14.98 | 16.88 | 17.58 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 7.05 | 8.47 | 9.06 | 9.99 | 11.94 | 12.33 | 13.72 | 15.47 | 16.11 |
| 24 | 1½ | **0.443** | **0.518** | **0.545** | **0.601** | **0.699** | **0.820** | **0.852** | **0.955** | **1.148** | **1.228** | **1.353** | **1.618** | **1.670** | **1.859** | **2.096** | **2.182** |
| | 1¾ | ...... | **0.444** | **0.468** | **0.515** | **0.599** | **0.703** | **0.731** | **0.819** | **0.983** | **1.052** | **1.160** | **1.387** | **1.431** | **1.593** | **1.796** | **1.870** |
| | 2 | ...... | ...... | ...... | **0.451** | **0.524** | **0.615** | **0.639** | **0.716** | **0.861** | **0.921** | **1.013** | **1.213** | **1.253** | **1.394** | **1.572** | **1.637** |
| | 2¼ | ...... | ...... | ...... | ...... | **0.466** | **0.547** | **0.568** | **0.637** | **0.765** | **0.818** | **0.902** | **1.078** | **1.114** | **1.240** | **1.397** | **1.455** |
| | 2½ | ...... | ...... | ...... | ...... | ...... | **0.492** | **0.512** | **0.574** | **0.688** | **0.737** | **0.812** | **0.970** | **1.002** | **1.117** | **1.257** | **1.309** |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | **0.465** | **0.521** | **0.626** | **0.670** | **0.738** | **0.882** | **0.912** | **1.014** | **1.142** | **1.191** |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.478** | **0.573** | **0.614** | **0.676** | **0.808** | **0.835** | **0.930** | **1.048** | **1.091** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1½ | 6.83 | 7.98 | 8.40 | 9.26 | 10.77 | 12.63 | 13.13 | 14.72 | 17.67 | 18.92 | 20.85 | 24.93 | 25.73 | 28.64 | 32.29 | 33.62 |
| | 1¾ | ... | 6.84 | 7.20 | 7.94 | 9.23 | 10.83 | 11.26 | 12.61 | 15.14 | 16.22 | 17.87 | 21.37 | 22.06 | 24.55 | 27.68 | 28.82 |
| | 2 | ... | ... | ... | 6.95 | 8.06 | 9.47 | 9.85 | 11.04 | 13.25 | 14.19 | 15.63 | 18.70 | 19.30 | 21.48 | 24.22 | 25.22 |
| | 2¼ | ... | ... | ... | ... | 7.17 | 8.41 | 8.75 | 9.81 | 11.78 | 12.61 | 13.90 | 16.62 | 17.15 | 19.09 | 21.53 | 22.41 |
| | 2½ | ... | ... | ... | ... | ... | 7.58 | 7.88 | 8.84 | 10.60 | 11.35 | 12.51 | 14.96 | 15.44 | 17.18 | 19.37 | 20.17 |
| | 2¾ | ... | ... | ... | ... | ... | ... | 7.16 | 8.03 | 9.64 | 10.31 | 11.37 | 13.60 | 14.04 | 15.63 | 17.61 | 18.34 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | 7.36 | 8.83 | 9.45 | 10.43 | 12.46 | 12.87 | 14.32 | 16.14 | 16.81 |
| 25 | **1½** | ... | **0.497** | **0.524** | **0.577** | **0.671** | **0.787** | **0.819** | **0.918** | **1.101** | **1.179** | **1.299** | **1.553** | **1.603** | **1.784** | **2.012** | **2.095** |
| | **1¾** | ... | ... | **0.499** | **0.495** | **0.575** | **0.675** | **0.701** | **0.786** | **0.943** | **1.010** | **1.112** | **1.331** | **1.374** | **1.530** | **1.724** | **1.796** |
| | **2** | ... | ... | ... | **0.443** | **0.503** | **0.590** | **0.614** | **0.688** | **0.826** | **0.884** | **0.973** | **1.163** | **1.202** | **1.338** | **1.509** | **1.571** |
| | **2¼** | ... | ... | ... | ... | **0.447** | **0.525** | **0.546** | **0.612** | **0.734** | **0.786** | **0.866** | **1.034** | **1.069** | **1.190** | **1.341** | **1.397** |
| | **2½** | ... | ... | ... | ... | ... | **0.472** | **0.491** | **0.550** | **0.661** | **0.708** | **0.779** | **0.932** | **0.962** | **1.071** | **1.208** | **1.258** |
| | **2¾** | ... | ... | ... | ... | ... | ... | **0.446** | **0.501** | **0.601** | **0.643** | **0.708** | **0.847** | **0.875** | **0.974** | **1.097** | **1.143** |
| | **3** | ... | ... | ... | ... | ... | ... | ... | **0.458** | **0.551** | **0.589** | **0.649** | **0.776** | **0.802** | **0.892** | **1.006** | **1.048** |
| | 1½ | ... | 8.30 | 8.75 | 9.65 | 11.21 | 13.16 | 13.68 | 15.33 | 18.40 | 19.71 | 21.72 | 25.97 | 26.80 | 29.83 | 33.63 | 35.02 |
| | 1¾ | ... | ... | 7.50 | 8.27 | 9.60 | 11.28 | 11.71 | 13.14 | 15.77 | 16.89 | 18.62 | 22.26 | 22.97 | 25.57 | 28.83 | 30.02 |
| | 2 | ... | ... | ... | 7.25 | 8.41 | 9.88 | 10.26 | 11.50 | 13.81 | 14.78 | 16.29 | 19.47 | 20.10 | 22.37 | 25.22 | 26.27 |
| | 2¼ | ... | ... | ... | ... | 7.18 | 8.77 | 9.12 | 10.23 | 12.27 | 13.14 | 11.48 | 17.31 | 17.87 | 19.89 | 22.42 | 23.35 |
| | 2½ | ... | ... | ... | ... | ... | 7.90 | 8.21 | 9.20 | 11.04 | 11.82 | 13.03 | 15.58 | 16.08 | 17.90 | 20.18 | 21.01 |
| | 2¾ | ... | ... | ... | ... | ... | ... | 7.46 | 8.37 | 10.04 | 10.74 | 11.85 | 14.16 | 14.62 | 16.27 | 18.35 | 19.11 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | 7.67 | 9.20 | 9.85 | 10.86 | 12.98 | 13.40 | 14.91 | 16.82 | 17.51 |
| 26 | **1½** | ... | **0.477** | **0.504** | **0.555** | **0.645** | **0.757** | **0.787** | **0.882** | **1.059** | **1.133** | **1.249** | **1.493** | **1.542** | **1.716** | **1.934** | **2.014** |
| | **1¾** | ... | ... | **0.432** | **0.476** | **0.553** | **0.649** | **0.675** | **0.756** | **0.907** | **0.972** | **1.071** | **1.280** | **1.321** | **1.471** | **1.658** | **1.727** |
| | **2** | ... | ... | ... | ... | **0.484** | **0.568** | **0.590** | **0.662** | **0.794** | **0.850** | **0.936** | **1.120** | **1.157** | **1.287** | **1.451** | **1.511** |
| | **2¼** | ... | ... | ... | ... | **0.430** | **0.505** | **0.525** | **0.583** | **0.706** | **0.756** | **0.832** | **0.995** | **1.029** | **1.144** | **1.290** | **1.343** |
| | **2½** | ... | ... | ... | ... | ... | **0.454** | **0.473** | **0.529** | **0.636** | **0.680** | **0.749** | **0.896** | **0.926** | **1.030** | **1.160** | **1.210** |
| | **2¾** | ... | ... | ... | ... | ... | ... | ... | **0.481** | **0.578** | **0.618** | **0.681** | **0.814** | **0.841** | **0.936** | **1.055** | **1.100** |
| | **3** | ... | ... | ... | ... | ... | ... | ... | **0.441** | **0.529** | **0.567** | **0.624** | **0.747** | **0.771** | **0.858** | **0.967** | **1.008** |
| | 1½ | ... | 8.64 | 9.11 | 10.03 | 11.67 | 13.69 | 14.23 | 15.95 | 19.14 | 20.49 | 22.59 | 27.00 | 27.88 | 31.03 | 34.98 | 36.43 |
| | 1¾ | ... | ... | 7.81 | 8.60 | 10.00 | 11.73 | 12.19 | 13.67 | 16.41 | 17.57 | 19.36 | 23.15 | 23.89 | 26.60 | 29.98 | 31.22 |
| | 2 | ... | ... | ... | ... | 8.75 | 10.27 | 10.67 | 11.96 | 14.36 | 15.37 | 16.94 | 20.25 | 20.91 | 23.27 | 26.23 | 27.32 |
| | 2¼ | ... | ... | ... | ... | 7.78 | 9.12 | 9.48 | 10.63 | 12.76 | 13.66 | 15.06 | 18.00 | 18.58 | 20.68 | 23.31 | 24.28 |
| | 2½ | ... | ... | ... | ... | ... | 8.21 | 8.54 | 9.57 | 11.48 | 12.30 | 13.56 | 16.20 | 16.73 | 18.62 | 20.99 | 21.86 |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | 8.70 | 10.44 | 11.18 | 12.32 | 14.73 | 15.20 | 16.92 | 19.08 | 19.87 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | 7.98 | 9.57 | 10.25 | 11.29 | 13.50 | 13.94 | 15.51 | 17.49 | 18.21 |
| 27 | **1½** | ... | ... | **0.485** | **0.534** | **0.621** | **0.729** | **0.758** | **0.849** | **1.020** | **1.091** | **1.202** | **1.438** | **1.484** | **1.652** | **1.863** | **1.940** |
| | **1¾** | ... | ... | ... | **0.458** | **0.532** | **0.625** | **0.650** | **0.728** | **0.874** | **0.936** | **1.031** | **1.232** | **1.272** | **1.416** | **1.597** | **1.663** |
| | **2** | ... | ... | ... | ... | **0.466** | **0.547** | **0.568** | **0.637** | **0.764** | **0.819** | **0.902** | **1.078** | **1.113** | **1.240** | **1.397** | **1.455** |
| | **2¼** | ... | ... | ... | ... | ... | **0.486** | **0.505** | **0.566** | **0.680** | **0.728** | **0.802** | **0.958** | **0.990** | **1.101** | **1.242** | **1.293** |
| | **2½** | ... | ... | ... | ... | ... | ... | **0.454** | **0.509** | **0.612** | **0.655** | **0.721** | **0.862** | **0.891** | **0.991** | **1.118** | **1.163** |
| | **2¾** | ... | ... | ... | ... | ... | ... | ... | **0.464** | **0.557** | **0.596** | **0.657** | **0.785** | **0.811** | **0.902** | **1.017** | **1.060** |
| | **3** | ... | ... | ... | ... | ... | ... | ... | **0.424** | **0.510** | **0.546** | **0.602** | **0.719** | **0.742** | **0.826** | **0.932** | **0.970** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire....... | | #4 | #3 | ¼″ | #2 | #1 | #0 | 5⁄16″ | #2/0 | #3/0 | ⅜″ | #4/0 | #5/0 | 7⁄16″ | #6/0 | #7/0 | ½″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches). | | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3928 | 0.4305 | 0.4375 | 0.4615 | 0.4900 | 0.5000 |
| Area (sq. in.).... | | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 | 0.1886 | 0.1964 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 27 | 1½ | ...... | ...... | 9.46 | 10.42 | 12.13 | 14.21 | 14.77 | 16.56 | 19.87 | 21.28 | 23.46 | 28.04 | 28.94 | 32.22 | 36.32 | 37.83 |
| | 1¾ | ...... | ...... | ...... | 8.93 | 10.38 | 12.18 | 12.66 | 14.20 | 17.04 | 18.24 | 20.11 | 24.04 | 24.81 | 27.62 | 31.14 | 32.42 |
| | 2 | ...... | ...... | ...... | ...... | 9.09 | 10.66 | 11.08 | 12.42 | 14.91 | 15.96 | 17.59 | 21.03 | 21.71 | 24.17 | 27.24 | 28.37 |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | 9.48 | 9.85 | 11.04 | 13.25 | 14.19 | 15.64 | 18.70 | 19.30 | 21.51 | 24.22 | 25.22 |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | 8.86 | 9.94 | 11.93 | 12.77 | 14.03 | 16.83 | 17.37 | 19.33 | 21.79 | 22.70 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 9.03 | 10.84 | 11.61 | 12.80 | 15.30 | 15.79 | 17.58 | 19.81 | 20.63 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 8.28 | 9.94 | 10.64 | 11.73 | 14.02 | 14.47 | 16.11 | 18.16 | 18.91 |
| 28 | 1½ | ...... | ...... | **0.467** | **0.515** | **0.599** | **0.703** | **0.731** | **0.819** | **0.983** | **1.053** | **1.160** | **1.387** | **1.432** | **1.593** | **1.796** | **1.870** |
| | 1¾ | ...... | ...... | ...... | **0.442** | **0.514** | **0.603** | **0.627** | **0.703** | **0.843** | **0.903** | **0.994** | **1.189** | **1.228** | **1.366** | **1.540** | **1.603** |
| | 2 | ...... | ...... | ...... | ...... | **0.449** | **0.527** | **0.548** | **0.614** | **0.737** | **0.899** | **0.869** | **1.040** | **1.074** | **1.197** | **1.347** | **1.403** |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | **0.469** | **0.487** | **0.546** | **0.655** | **0.702** | **0.773** | **0.924** | **0.955** | **1.062** | **1.198** | **1.248** |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.492** | **0.590** | **0.632** | **0.696** | **0.832** | **0.859** | **0.956** | **1.078** | **1.122** |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.447** | **0.536** | **0.574** | **0.632** | **0.756** | **0.781** | **0.869** | **0.980** | **1.020** |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.492** | **0.526** | **0.580** | **0.693** | **0.716** | **0.797** | **0.898** | **0.935** |
| | 1½ | ...... | ...... | 9.81 | 10.81 | 12.56 | 14.74 | 15.32 | 17.18 | 20.61 | 22.07 | 24.33 | 29.08 | 30.02 | 33.41 | 37.67 | 39.23 |
| | 1¾ | ...... | ...... | ...... | 9.26 | 10.77 | 12.64 | 13.13 | 14.72 | 17.67 | 18.92 | 20.85 | 24.93 | 25.73 | 28.64 | 32.29 | 33.63 |
| | 2 | ...... | ...... | ...... | ...... | 9.42 | 11.06 | 11.49 | 12.88 | 15.46 | 16.55 | 18.24 | 21.81 | 22.52 | 25.06 | 28.25 | 29.42 |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | 9.83 | 10.21 | 11.45 | 13.74 | 14.71 | 16.22 | 19.39 | 20.01 | 22.28 | 25.11 | 26.15 |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 10.31 | 12.37 | 13.24 | 14.60 | 17.45 | 18.01 | 20.05 | 22.60 | 23.54 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 9.37 | 11.24 | 12.04 | 13.27 | 15.86 | 16.37 | 18.23 | 20.55 | 21.40 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 10.31 | 11.04 | 12.16 | 14.54 | 15.01 | 16.71 | 18.83 | 19.61 |
| 29 | 1½ | ...... | ...... | ...... | **0.497** | **0.578** | **0.679** | **0.705** | **0.790** | **0.950** | **1.015** | **1.119** | **1.339** | **1.382** | **1.538** | **1.734** | **1.806** |
| | 1¾ | ...... | ...... | ...... | ...... | **0.496** | **0.582** | **0.605** | **0.678** | **0.814** | **0.870** | **0.959** | **1.147** | **1.185** | **1.319** | **1.487** | **1.548** |
| | 2 | ...... | ...... | ...... | ...... | **0.434** | **0.508** | **0.529** | **0.593** | **0.712** | **0.762** | **0.840** | **1.003** | **1.037** | **1.153** | **1.301** | **1.354** |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | **0.452** | **0.471** | **0.527** | **0.633** | **0.678** | **0.746** | **0.893** | **0.922** | **1.027** | **1.157** | **1.204** |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.474** | **0.570** | **0.610** | **0.672** | **0.804** | **0.830** | **0.924** | **1.040** | **1.084** |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.432** | **0.518** | **0.554** | **0.611** | **0.730** | **0.754** | **0.840** | **0.946** | **0.986** |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.474** | **0.508** | **0.559** | **0.669** | **0.691** | **0.769** | **0.867** | **0.904** |

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# PERCENTAGE OF VOLUME OF CORE
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| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1½ | ...... | ...... | ...... | 11.19 | 13.01 | 15.27 | 15.87 | 17.79 | 21.35 | 22.85 | 25.20 | 30.12 | 31.09 | 34.61 | 39.02 | 40.63 |
| | 1¾ | ...... | ...... | ...... | ...... | 11.15 | 13.09 | 13.60 | 15.25 | 18.30 | 19.59 | 21.60 | 25.82 | 26.65 | 29.66 | 33.44 | 34.82 |
| | 2 | ...... | ...... | ...... | ...... | 9.76 | 11.45 | 11.90 | 13.34 | 16.01 | 17.14 | 18.90 | 22.59 | 23.32 | 25.96 | 29.26 | 30.47 |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | 10.18 | 10.58 | 11.86 | 14.23 | 15.24 | 16.80 | 20.08 | 20.73 | 23.07 | 26.01 | 27.09 |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 10.68 | 12.81 | 13.71 | 15.12 | 18.07 | 18.66 | 20.77 | 23.41 | 24.38 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 9.70 | 11.64 | 12.47 | 13.74 | 16.43 | 16.96 | 18.88 | 21.28 | 22.16 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 10.68 | 11.43 | 12.60 | 15.06 | 15.55 | 17.30 | 19.51 | 20.31 |
| 30 | 1½ | ...... | ...... | ...... | **0.481** | **0.559** | **0.656** | **0.682** | **0.764** | **0.917** | **0.982** | **1.081** | **1.294** | **1.336** | **1.487** | **1.676** | **1.746** |
| | 1¾ | ...... | ...... | ...... | ...... | **0.479** | **0.562** | **0.584** | **0.655** | **0.786** | **0.842** | **0.927** | **1.109** | **1.145** | **1.275** | **1.437** | **1.496** |
| | 2 | ...... | ...... | ...... | ...... | ...... | **0.492** | **0.512** | **0.573** | **0.688** | **0.737** | **0.812** | **0.970** | **1.002** | **1.116** | **1.257** | **1.309** |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | ...... | **0.455** | **0.510** | **0.612** | **0.656** | **0.722** | **0.863** | **0.891** | **0.992** | **1.119** | **1.165** |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.458** | **0.551** | **0.589** | **0.649** | **0.776** | **0.802** | **0.893** | **1.006** | **1.048** |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.417** | **0.501** | **0.536** | **0.590** | **0.706** | **0.729** | **0.811** | **0.914** | **0.952** |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.459** | **0.491** | **0.541** | **0.646** | **0.668** | **0.743** | **0.838** | **0.873** |
| | 1½ | ...... | ...... | ...... | 11.58 | 13.46 | 15.79 | 16.41 | 18.40 | 22.09 | 23.65 | 26.07 | 31.16 | 32.16 | 35.80 | 40.36 | 42.03 |
| | 1¾ | ...... | ...... | ...... | ...... | 11.54 | 13.54 | 14.07 | 15.78 | 18.93 | 20.27 | 22.34 | 26.71 | 27.57 | 30.69 | 34.59 | 36.02 |
| | 2 | ...... | ...... | ...... | ...... | ...... | 11.84 | 12.31 | 13.80 | 16.56 | 17.74 | 19.55 | 23.37 | 24.12 | 26.85 | 30.27 | 31.52 |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | ...... | 10.94 | 12.28 | 14.72 | 15.76 | 17.38 | 20.77 | 21.44 | 23.87 | 26.91 | 28.02 |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 11.02 | 13.25 | 14.19 | 15.64 | 18.70 | 19.30 | 21.48 | 24.22 | 25.22 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 10.04 | 12.05 | 12.90 | 14.22 | 17.00 | 17.54 | 19.53 | 22.01 | 22.93 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 11.04 | 11.82 | 13.03 | 15.58 | 16.08 | 17.90 | 20.18 | 21.01 |
| 31 | 1½ | ...... | ...... | ...... | **0.465** | **0.541** | **0.635** | **0.660** | **0.740** | **0.888** | **0.950** | **1.048** | **1.252** | **1.293** | **1.439** | **1.622** | **1.689** |
| | 1¾ | ...... | ...... | ...... | ...... | **0.464** | **0.544** | **0.566** | **0.634** | **0.761** | **0.815** | **0.898** | **1.072** | **1.109** | **1.233** | **1.391** | **1.448** |
| | 2 | ...... | ...... | ...... | ...... | ...... | **0.476** | **0.495** | **0.555** | **0.666** | **0.713** | **0.785** | **0.939** | **0.970** | **1.080** | **1.217** | **1.267** |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.493** | **0.592** | **0.634** | **0.698** | **0.835** | **0.862** | **0.960** | **1.082** | **1.128** |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.444** | **0.533** | **0.570** | **0.628** | **0.751** | **0.776** | **0.864** | **0.974** | **1.013** |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.484** | **0.518** | **0.570** | **0.683** | **0.706** | **0.785** | **0.885** | **0.922** |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.475** | **0.524** | **0.626** | **0.647** | **0.720** | **0.812** | **0.845** |
| | 1½ | ...... | ...... | ...... | 11.96 | 13.91 | 16.32 | 16.96 | 19.02 | 22.82 | 24.43 | 26.93 | 32.20 | 33.24 | 37.00 | 41.71 | 43.43 |
| | 1¾ | ...... | ...... | ...... | ...... | 11.92 | 13.99 | 14.54 | 16.30 | 19.56 | 20.94 | 23.09 | 27.60 | 28.49 | 31.71 | 35.75 | 37.23 |
| | 2 | ...... | ...... | ...... | ...... | ...... | 12.23 | 12.72 | 14.26 | 17.12 | 18.33 | 20.20 | 24.15 | 24.93 | 27.75 | 31 28 | 32.57 |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 12.68 | 15.21 | 16.29 | 17.96 | 21.46 | 22.16 | 24.66 | 27.80 | 28.96 |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 11.41 | 13.69 | 14.69 | 16.16 | 19.32 | 19.94 | 22.20 | 25.02 | 26.06 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 12.45 | 13.33 | 14.69 | 17.56 | 18.13 | 20.18 | 22.75 | 23.69 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 12.22 | 13.47 | 16.10 | 16.62 | 18.50 | 20.85 | 21.72 |
| 32 | 1½ | ...... | ...... | ...... | **0.451** | **0.524** | **0.615** | **0.639** | **0.717** | **0.861** | **0.921** | **1.014** | **1.212** | **1.253** | **1.394** | **1.572** | **1.637** |
| | 1¾ | ...... | ...... | ...... | ...... | **0.449** | **0.527** | **0.548** | **0.614** | **0.738** | **0.790** | **0.870** | **1.040** | **1.073** | **1.195** | **1.347** | **1.400** |
| | 2 | ...... | ...... | ...... | ...... | ...... | **0.461** | **0.479** | **0.537** | **0.646** | **0.691** | **0.761** | **0.909** | **0.940** | **1.047** | **1.179** | **1.229** |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.478** | **0.574** | **0.614** | **0.676** | **0.809** | **0.836** | **0.930** | **1.049** | **1.092** |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.430** | **0.516** | **0.552** | **0.609** | **0.728** | **0.751** | **0.836** | **0.943** | **0.982** |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.469** | **0.503** | **0.554** | **0.662** | **0.684** | **0.761** | **0.858** | **0.893** |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.460** | **0.507** | **0.607** | **0.626** | **0.698** | **0.786** | **0.819** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire | | #4 | #3 | ¼″ | #2 | #1 | #0 | 5⁄16″ | #2/0 | #3/0 | 3⁄8″ | #4/0 | #5/0 | 7⁄16″ | #6/0 | #7/0 | ½″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches) | | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3928 | 0.4305 | 0.4375 | 0.4615 | 0.4900 | 0.5000 |
| Area (sq. in.) | | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 | 0.1886 | 0.1964 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 32 | 1½ | ... | ... | ... | 12.35 | 14.36 | 16.84 | 17.51 | 19.63 | 23.56 | 25.22 | 27.80 | 33.24 | 34.31 | 38.19 | 43.05 | 44.83 |
| | 1¾ | ... | ... | ... | ... | 12.31 | 14.44 | 15.01 | 16.83 | 20.19 | 21.62 | 23.83 | 28.49 | 29.40 | 32.73 | 36.90 | 38.43 |
| | 2 | ... | ... | ... | ... | ... | 12.63 | 13.13 | 14.72 | 17.67 | 18.92 | 20.85 | 24.93 | 25.73 | 28.64 | 32.29 | 33.62 |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | 13.09 | 15.70 | 16.82 | 18.54 | 22.16 | 22.87 | 25.46 | 28.70 | 29.89 |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | 11.78 | 14.13 | 15.13 | 16.68 | 19.94 | 20.59 | 22.91 | 25.83 | 26.90 |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | 12.85 | 13.76 | 15.17 | 18.13 | 18.71 | 20.83 | 23.48 | 24.46 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 12.61 | 13.90 | 16.62 | 17.16 | 19.09 | 21.53 | 22.42 |
| 33 | 1½ | ... | ... | ... | **0.437** | **0.508** | **0.596** | **0.620** | **0.695** | **0.835** | **0.893** | **0.984** | **1.176** | **1.215** | **1.352** | **1.524** | **1.587** |
| | 1¾ | ... | ... | ... | ... | **0.425** | **0.511** | **0.531** | **0.596** | **0.715** | **0.765** | **0.844** | **1.008** | **1.041** | **1.159** | **1.306** | **1.360** |
| | 2 | ... | ... | ... | ... | ... | **0.447** | **0.465** | **0.521** | **0.626** | **0.669** | **0.737** | **0.882** | **0.912** | **1.014** | **1.142** | **1.191** |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | **0.463** | **0.556** | **0.595** | **0.656** | **0.784** | **0.810** | **0.902** | **1.015** | **1.058** |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | **0.417** | **0.501** | **0.536** | **0.590** | **0.706** | **0.729** | **0.812** | **0.915** | **0.952** |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | **0.456** | **0.487** | **0.537** | **0.642** | **0.663** | **0.738** | **0.831** | **0.866** |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.492** | **0.588** | **0.607** | **0.677** | **0.762** | **0.794** |
| | 1½ | ... | ... | ... | 12.74 | 14.81 | 17.37 | 18.06 | 20.24 | 24.29 | 26.01 | 28.67 | 34.27 | 35.38 | 39.38 | 44.40 | 46.23 |
| | 1¾ | ... | ... | ... | ... | 12.69 | 14.89 | 15.48 | 17.35 | 20.82 | 22.30 | 24.58 | 29.38 | 30.33 | 33.76 | 38.06 | 39.63 |
| | 2 | ... | ... | ... | ... | ... | 13.03 | 13.51 | 15.18 | 18.22 | 19.51 | 21.50 | 25.71 | 26.54 | 29.54 | 33.30 | 34.67 |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | 13.50 | 16.19 | 17.34 | 19.11 | 22.85 | 23.59 | 26.26 | 29.60 | 30.82 |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | 12.15 | 14.58 | 15.61 | 17.20 | 20.56 | 21.23 | 23.63 | 26.64 | 27.74 |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | 13.25 | 14.19 | 15.64 | 18.70 | 19.30 | 21.48 | 24.22 | 25.22 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 14.34 | 17.14 | 17.69 | 19.69 | 22.20 | 23.12 |
| 34 | 1½ | ... | ... | ... | ... | **0.493** | **0.579** | **0.602** | **0.675** | **0.810** | **0.867** | **0.955** | **1.141** | **1.180** | **1.312** | **1.479** | **1.540** |
| | 1¾ | ... | ... | ... | ... | ... | **0.496** | **0.516** | **0.578** | **0.695** | **0.743** | **0.819** | **0.979** | **1.010** | **1.125** | **1.268** | **1.320** |
| | 2 | ... | ... | ... | ... | ... | ... | **0.451** | **0.506** | **0.607** | **0.650** | **0.716** | **0.856** | **0.884** | **0.984** | **1.109** | **1.156** |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | **0.449** | **0.539** | **0.578** | **0.636** | **0.761** | **0.786** | **0.875** | **0.986** | **1.026** |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | ... | **0.486** | **0.520** | **0.573** | **0.685** | **0.707** | **0.787** | **0.887** | **0.925** |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.473** | **0.521** | **0.623** | **0.643** | **0.716** | **0.807** | **0.840** |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.478** | **0.571** | **0.589** | **0.656** | **0.739** | **0.771** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1½ | | | | | 15.26 | 17.90 | 18.60 | 20.86 | 25.03 | 26.80 | 29.54 | 35.31 | 36.46 | 40.58 | 45.74 | 47.63 |
| | 1¾ | | | | | | 15.34 | 15.94 | 17.88 | 21.46 | 22.97 | 25.32 | 30.27 | 31.24 | 34.78 | 39.21 | 40.83 |
| | 2 | | | | | | | 13.95 | 15.64 | 18.77 | 20.10 | 22.16 | 26.48 | 27.34 | 30.43 | 34.31 | 35.73 |
| | 2¼ | | | | | | | | 13.90 | 16.68 | 17.87 | 19.69 | 23.54 | 24.30 | 27.05 | 30.49 | 31.76 |
| | 2½ | | | | | | | | | 15.02 | 16.08 | 17.72 | 21.19 | 21.87 | 24.34 | 27.44 | 28.58 |
| | 2¾ | | | | | | | | | | 14.62 | 16.11 | 19.26 | 19.88 | 22.14 | 24.95 | 25.98 |
| | 3 | | | | | | | | | | | 14.77 | 17.66 | 18.23 | 20.29 | 22.87 | 23.82 |
| 35 | 1½ | | | | | **0.479** | **0.562** | **0.585** | **0.655** | **0.787** | **0.843** | **0.928** | **1.110** | **1.147** | **1.275** | **1.437** | **1.496** |
| | 1¾ | | | | | | **0.482** | **0.501** | **0.562** | **0.674** | **0.722** | **0.795** | **0.950** | **0.982** | **1.092** | **1.231** | **1.282** |
| | 2 | | | | | | | **0.438** | **0.492** | **0.590** | **0.631** | **0.696** | **0.832** | **0.860** | **0.956** | **1.078** | **1.122** |
| | 2¼ | | | | | | | | **0.437** | **0.525** | **0.562** | **0.618** | **0.740** | **0.764** | **0.850** | **0.958** | **0.999** |
| | 2½ | | | | | | | | | **0.472** | **0.505** | **0.557** | **0.665** | **0.688** | **0.765** | **0.862** | **0.899** |
| | 2¾ | | | | | | | | | | **0.459** | **0.506** | **0.605** | **0.625** | **0.696** | **0.784** | **0.817** |
| | 3 | | | | | | | | | | | **0.463** | **0.554** | **0.573** | **0.638** | **0.718** | **0.749** |
| | 1½ | | | | | 15.70 | 18.43 | 19.15 | 21.47 | 25.77 | 27.59 | 30.34 | 36.35 | 37.53 | 41.77 | 47.09 | 49.04 |
| | 1¾ | | | | | | 15.80 | 16.41 | 18.40 | 22.08 | 23.64 | 26.07 | 31.16 | 32.16 | 35.80 | 40.36 | 42.03 |
| | 2 | | | | | | | 14.36 | 16.10 | 19.32 | 20.69 | 22.80 | 27.26 | 28.14 | 31.33 | 35.32 | 36.78 |
| | 2¼ | | | | | | | | 14.31 | 17.18 | 18.39 | 20.27 | 24.23 | 25.02 | 27.83 | 31.39 | 32.69 |
| | 2½ | | | | | | | | | 15.46 | 16.56 | 18.24 | 21.81 | 22.52 | 25.06 | 28.25 | 29.42 |
| | 2¾ | | | | | | | | | | 15.05 | 16.59 | 19.83 | 20.47 | 22.78 | 25.68 | 26.74 |
| | 3 | | | | | | | | | | | 15.20 | 18.18 | 18.76 | 20.88 | 23.54 | 24.52 |
| 36 | 1½ | | | | | **0.466** | **0.547** | **0.569** | **0.637** | **0.765** | **0.819** | **0.902** | **1.078** | **1.112** | **1.240** | **1.397** | **1.455** |
| | 1¾ | | | | | | **0.469** | **0.487** | **0.546** | **0.656** | **0.702** | **0.773** | **0.924** | **0.955** | **1.062** | **1.198** | **1.248** |
| | 2 | | | | | | | | **0.478** | **0.573** | **0.614** | **0.676** | **0.809** | **0.835** | **0.930** | **1.048** | **1.092** |
| | 2¼ | | | | | | | | **0.425** | **0.510** | **0.546** | **0.601** | **0.719** | **0.742** | **0.826** | **0.931** | **0.970** |
| | 2½ | | | | | | | | | **0.459** | **0.492** | **0.541** | **0.647** | **0.668** | **0.743** | **0.838** | **0.873** |
| | 2¾ | | | | | | | | | | | **0.493** | **0.588** | **0.608** | **0.676** | **0.762** | **0.794** |
| | 3 | | | | | | | | | | | **0.451** | **0.539** | **0.557** | **0.620** | **0.699** | **0.728** |
| | 1½ | | | | | 16.13 | 18.93 | 19.69 | 22.05 | 26.47 | 28.34 | 31.22 | 37.31 | 38.49 | 42.91 | 48.35 | 50.36 |
| | 1¾ | | | | | | 16.23 | 16.85 | 18.90 | 22.70 | 24.30 | 26.75 | 31.98 | 32.95 | 36.76 | 41.46 | 43.19 |
| | 2 | | | | | | | | 16.54 | 19.84 | 21.25 | 23.40 | 28.00 | 28.90 | 32.19 | 36.27 | 37.79 |
| | 2¼ | | | | | | | | 14.71 | 17.65 | 18.90 | 20.80 | 24.88 | 25.68 | 28.59 | 28.94 | 33.51 |
| | 2½ | | | | | | | | | 15.88 | 17.03 | 18.72 | 22.39 | 23.12 | 28.62 | 29.00 | 30.21 |
| | 2¾ | | | | | | | | | | | 17.06 | 20.37 | 21.04 | 23.40 | 26.37 | 27.48 |
| | 3 | | | | | | | | | | | 15.61 | 18.65 | 19.28 | 21.46 | 24.19 | 25.19 |
| 37 | 1½ | | | | | **0.453** | **0.532** | **0.553** | **0.620** | **0.744** | **0.797** | **0.878** | **1.049** | **1.083** | **1.206** | **1.359** | **1.415** |
| | 1¾ | | | | | | **0.456** | **0.474** | **0.531** | **0.638** | **0.683** | **0.752** | **0.899** | **0.929** | **1.033** | **1.164** | **1.214** |
| | 2 | | | | | | | | **0.465** | **0.558** | **0.598** | **0.658** | **0.787** | **0.813** | **0.905** | **1.019** | **1.061** |
| | 2¼ | | | | | | | | | **0.496** | **0.531** | **0.585** | **0.699** | **0.722** | **0.804** | **0.906** | **0.944** |
| | 2½ | | | | | | | | | | **0.478** | **0.526** | **0.629** | **0.650** | **0.724** | **0.816** | **0.850** |
| | 2¾ | | | | | | | | | | | **0.479** | **0.573** | **0.591** | **0.658** | **0.741** | **0.772** |
| | 3 | | | | | | | | | | | **0.439** | **0.524** | **0.542** | **0.603** | **0.680** | **0.708** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire....... | | #4 | #3 | ¼″ | #2 | #1 | #0 | 5⁄16″ | #2/0 | #3/0 | ⅜″ | #4/0 | #5/0 | 7⁄16″ | #6/0 | #7/0 | ½″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches). | | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3938 | 0.4305 | 0.4375 | 0.4615 | 0.4900 | 0.5000 |
| Area (sq. in.)..... | | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 | 0.1886 | 0.1964 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 37 | 1½ | ...... | ...... | ...... | ...... | 16.60 | 19.48 | 20.24 | 22.70 | 27.23 | 29.17 | 32.15 | 38.43 | 39.67 | 44.16 | 49.78 | 51.84 |
| | 1¾ | ...... | ...... | ...... | ...... | ...... | 16.70 | 17.35 | 19.46 | 23.35 | 25.00 | 27.56 | 32.94 | 34.00 | 37.85 | 42.66 | 44.43 |
| | 2 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 17.02 | 20.43 | 21.88 | 24.11 | 28.82 | 29.76 | 33.12 | 37.33 | 38.88 |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 18.16 | 19.44 | 21.43 | 25.62 | 26.44 | 29.44 | 33.19 | 34.56 |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 17.50 | 19.29 | 23.06 | 23.81 | 26.49 | 29.87 | 31.10 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 17.53 | 20.96 | 21.64 | 24.09 | 27.15 | 28.27 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 16.07 | 19.21 | 19.83 | 22.08 | 24.89 | 25.92 |
| 38 | **1½** | ...... | ...... | ...... | ...... | **0.441** | **0.518** | **0.538** | **0.604** | **0.724** | **0.776** | **0.854** | **1.021** | **1.054** | **1.173** | **1.323** | **1.378** |
| | **1¾** | ...... | ...... | ...... | ...... | ...... | **0.444** | **0.462** | **0.517** | **0.621** | **0.665** | **0.732** | **0.876** | **0.904** | **1.007** | **1.123** | **1.181** |
| | **2** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.452** | **0.543** | **0.582** | **0.640** | **0.766** | **0.791** | **0.881** | **0.993** | **1.033** |
| | **2¼** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.483** | **0.517** | **0.569** | **0.681** | **0.704** | **0.783** | **0.882** | **0.919** |
| | **2½** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.466** | **0.512** | **0.613** | **0.633** | **0.705** | **0.794** | **0.827** |
| | **2¾** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.467** | **0.558** | **0.576** | **0.641** | **0.723** | **0.753** |
| | **3** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.427** | **0.511** | **0.528** | **0.587** | **0.662** | **0.689** |
| | 1½ | ...... | ...... | ...... | ...... | 17.05 | 20.01 | 20.79 | 23.31 | 27.98 | 29.96 | 33.02 | 39.47 | 40.74 | 45.35 | 51.12 | 53.24 |
| | 1¾ | ...... | ...... | ...... | ...... | ...... | 17.15 | 17.82 | 19.98 | 23.98 | 25.67 | 28.30 | 33.83 | 34.92 | 38.87 | 43.82 | 45.63 |
| | 2 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 17.48 | 20.98 | 22.46 | 24.76 | 29.60 | 30.56 | 34.01 | 38.34 | 39.93 |
| | 2¼ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 18.65 | 19.97 | 22.01 | 26.31 | 27.16 | 30.23 | 34.08 | 35.49 |
| | 2½ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 17.97 | 19.81 | 23.68 | 24.44 | 27.21 | 30.67 | 31.94 |
| | 2¾ | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 18.01 | 21.53 | 22.22 | 24.74 | 27.89 | 29.04 |
| | 3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 16.51 | 19.73 | 20.37 | 22.67 | 25.56 | 26.62 |
| 39 | **1½** | ...... | ...... | ...... | ...... | **0.430** | **0.504** | **0.525** | **0.588** | **0.706** | **0.755** | **0.832** | **0.995** | **1.028** | **1.143** | **1.290** | **1.343** |
| | **1¾** | ...... | ...... | ...... | ...... | ...... | **0.433** | **0.449** | **0.504** | **0.605** | **0.648** | **0.713** | **0.853** | **0.881** | **0.981** | **1.105** | **1.151** |
| | **2** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.441** | **0.529** | **0.567** | **0.624** | **0.746** | **0.771** | **0.858** | **0.967** | **1.008** |
| | **2¼** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.471** | **0.504** | **0.555** | **0.664** | **0.686** | **0.763** | **0.860** | **0.896** |
| | **2½** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.453** | **0.499** | **0.597** | **0.617** | **0.686** | **0.773** | **0.806** |
| | **2¾** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.454** | **0.543** | **0.561** | **0.624** | **0.703** | **0.733** |
| | **3** | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **0.498** | **0.514** | **0.572** | **0.644** | **0.671** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

**HEAVY TYPE GIVES PERCENTAGES**
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1½ | ... | ... | ... | ... | 17.50 | 20.53 | 21.34 | 23.93 | 28.71 | 30.74 | 33.89 | 40.51 | 41.82 | 46.54 | 52.47 | 54.64 |
| | 1¾ | ... | ... | ... | ... | ... | 17.60 | 18.29 | 20.51 | 24.61 | 26.35 | 29.04 | 34.72 | 35.84 | 39.90 | 44.97 | 46.83 |
| | 2 | ... | ... | ... | ... | ... | ... | ... | 17.94 | 21.53 | 23.06 | 25.41 | 30.38 | 31.36 | 34.91 | 30.35 | 40.98 |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | ... | 19.14 | 20.49 | 22.59 | 27.00 | 27.88 | 31.03 | 34.98 | 36.43 |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | ... | ... | 18.44 | 20.33 | 24.30 | 25.09 | 27.93 | 31.48 | 32.78 |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 18.48 | 22.09 | 22.81 | 25.39 | 28.62 | 29.80 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 20.25 | 20.91 | 23.27 | 26.23 | 27.32 |
| 40 | **1½** | ... | ... | ... | ... | ... | **0.492** | **0.511** | **0.573** | **0.688** | **0.736** | **0.811** | **0.970** | **1.002** | **1.116** | **1.257** | **1.309** |
| | **1¾** | ... | ... | ... | ... | ... | ... | **0.438** | **0.491** | **0.590** | **0.632** | **0.696** | **0.832** | **0.860** | **0.956** | **1.078** | **1.122** |
| | **2** | ... | ... | ... | ... | ... | ... | ... | **0.430** | **0.516** | **0.553** | **0.609** | **0.728** | **0.752** | **0.837** | **0.943** | **0.982** |
| | **2¼** | ... | ... | ... | ... | ... | ... | ... | ... | **0.459** | **0.491** | **0.541** | **0.647** | **0.668** | **0.744** | **0.838** | **0.873** |
| | **2½** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.487** | **0.582** | **0.602** | **0.670** | **0.754** | **0.786** |
| | **2¾** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.442** | **0.529** | **0.547** | **0.609** | **0.686** | **0.724** |
| | **3** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.485** | **0.501** | **0.558** | **0.629** | **0.655** |
| | 1½ | ... | ... | ... | ... | ... | 21.06 | 21.88 | 24.54 | 29.45 | 31.53 | 34.76 | 41.54 | 42.89 | 47.74 | 53.81 | 56.04 |
| | 1¾ | ... | ... | ... | ... | ... | ... | 18.76 | 21.03 | 25.24 | 27.03 | 29.79 | 35.61 | 36.76 | 40.92 | 46.15 | 48.03 |
| | 2 | ... | ... | ... | ... | ... | ... | ... | 18.40 | 22.09 | 23.65 | 26.07 | 31.16 | 32.16 | 35.81 | 40.36 | 42.03 |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | ... | 19.63 | 21.03 | 23.17 | 27.70 | 28.59 | 31.82 | 35.88 | 37.36 |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 20.86 | 24.93 | 25.73 | 28.64 | 32.29 | 33.63 |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 18.96 | 22.66 | 23.39 | 26.04 | 29.35 | 30.57 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 20.77 | 21.44 | 23.87 | 26.91 | 28.02 |
| 41 | **1½** | ... | ... | ... | ... | ... | ... | **0.499** | **0.560** | **0.672** | **0.719** | **0.791** | **0.948** | **0.979** | **1.089** | **1.227** | **1.277** |
| | **1¾** | ... | ... | ... | ... | ... | ... | ... | **0.479** | **0.576** | **0.616** | **0.678** | **0.811** | **0.838** | **0.933** | **1.051** | **1.094** |
| | **2** | ... | ... | ... | ... | ... | ... | ... | **0.419** | **0.503** | **0.539** | **0.594** | **0.710** | **0.734** | **0.817** | **0.920** | **0.959** |
| | **2¼** | ... | ... | ... | ... | ... | ... | ... | ... | **0.448** | **0.479** | **0.528** | **0.631** | **0.652** | **0.726** | **0.818** | **0.852** |
| | **2½** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.475** | **0.568** | **0.587** | **0.653** | **0.736** | **0.766** |
| | **2¾** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.432** | **0.516** | **0.533** | **0.594** | **0.669** | **0.697** |
| | **3** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.473** | **0.489** | **0.544** | **0.613** | **0.639** |
| | 1½ | ... | ... | ... | ... | ... | ... | 22.43 | 25.15 | 30.18 | 32.32 | 35.62 | 42.58 | 43.86 | 48.93 | 55.16 | 57.44 |
| | 1¾ | ... | ... | ... | ... | ... | ... | ... | 21.56 | 25.87 | 27.70 | 30.53 | 36.50 | 37.68 | 41.94 | 47.28 | 49.24 |
| | 2 | ... | ... | ... | ... | ... | ... | ... | 18.86 | 22.64 | 24.24 | 26.72 | 31.94 | 32.97 | 36.70 | 41.37 | 43.08 |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | ... | 20.12 | 21.56 | 23.75 | 28.39 | 29.31 | 32.62 | 36.77 | 38.29 |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 21.37 | 25.55 | 26.38 | 29.36 | 33.10 | 34.47 |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 19.43 | 23.23 | 23.98 | 26.69 | 30.09 | 31.33 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 21.29 | 21.98 | 24.47 | 27.58 | 28.72 |
| 42 | **1½** | ... | ... | ... | ... | ... | ... | **0.487** | **0.546** | **0.656** | **0.702** | **0.773** | **0.925** | **0.955** | **1.062** | **1.198** | **1.248** |
| | **1¾** | ... | ... | ... | ... | ... | ... | ... | **0.468** | **0.562** | **0.601** | **0.663** | **0.792** | **0.818** | **0.910** | **1.026** | **1.069** |
| | **2** | ... | ... | ... | ... | ... | ... | ... | ... | **0.492** | **0.526** | **0.579** | **0.693** | **0.716** | **0.797** | **0.898** | **0.936** |
| | **2¼** | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.468** | **0.515** | **0.616** | **0.637** | **0.709** | **0.798** | **0.832** |
| | **2½** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.464** | **0.554** | **0.573** | **0.638** | **0.718** | **0.748** |
| | **2¾** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.422** | **0.504** | **0.521** | **0.579** | **0.653** | **0.681** |
| | **3** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.462** | **0.477** | **0.531** | **0.599** | **0.624** |

## COLUMN SPIRALS
## PERCENTAGE OF VOLUME OF CORE
## AND
## WEIGHT IN POUNDS PER FOOT OF COLUMN

**HEAVY TYPE GIVES PERCENTAGES**
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire....... | | #4 | #3 | ¼″ | #2 | #1 | #0 | 5⁄16″ | #2/0 | #3/0 | ⅜″ | #4/0 | #5/0 | 7⁄16″ | #6/0 | #7/0 | ½″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches). | | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3938 | 0.4305 | 0.4375 | 0.4615 | 0.4900 | 0.5000 |
| Area (sq. in.)..... | | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 | 0.1886 | 0.1964 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 42 | 1½ | ... | ... | ... | ... | ... | ... | 22.98 | 25.77 | 30.92 | 33.11 | 36.49 | 43.62 | 45.03 | 50.12 | 56.50 | 58.84 |
| | 1¾ | ... | ... | ... | ... | ... | ... | ... | 22.08 | 26.50 | 28.38 | 31.28 | 37.39 | 38.60 | 42.96 | 48.43 | 50.44 |
| | 2 | ... | ... | ... | ... | ... | ... | ... | ... | 23.19 | 24.83 | 27.37 | 32.72 | 33.77 | 37.59 | 42.38 | 44.13 |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | ... | ... | 22.07 | 24.33 | 29.08 | 30.02 | 33.42 | 37.67 | 39.23 |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 21.90 | 26.17 | 27.02 | 30.07 | 33.90 | 35.30 |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 19.90 | 23.79 | 24.56 | 27.34 | 30.82 | 32.10 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 21.81 | 22.51 | 25.06 | 28.25 | 29.42 |
| 43 | **1½** | ... | ... | ... | ... | ... | ... | **0.476** | **0.533** | **0.640** | **0.685** | **0.754** | **0.902** | **0.932** | **1.038** | **1.170** | **1.219** |
| | **1¾** | ... | ... | ... | ... | ... | ... | ... | **0.457** | **0.549** | **0.588** | **0.647** | **0.773** | **0.799** | **0.890** | **1.002** | **1.044** |
| | **2** | ... | ... | ... | ... | ... | ... | ... | ... | **0.480** | **0.514** | **0.566** | **0.677** | **0.699** | **0.778** | **0.877** | **0.914** |
| | **2¼** | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.457** | **0.503** | **0.602** | **0.621** | **0.692** | **0.780** | **0.813** |
| | **2½** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.453** | **0.541** | **0.559** | **0.623** | **0.702** | **0.731** |
| | **2¾** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.492** | **0.508** | **0.566** | **0.638** | **0.665** |
| | **3** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.466** | **0.519** | **0.584** | **0.609** |
| | 1½ | ... | ... | ... | ... | ... | ... | 23.53 | 26.38 | 31.65 | 33.90 | 37.36 | 44.66 | 46.10 | 51.31 | 57.85 | 60.24 |
| | 1¾ | ... | ... | ... | ... | ... | ... | ... | 22.61 | 27.13 | 29.05 | 32.02 | 38.28 | 39.52 | 43.99 | 49.59 | 51.64 |
| | 2 | ... | ... | ... | ... | ... | ... | ... | ... | 23.74 | 25.42 | 28.02 | 33.50 | 34.58 | 38.49 | 43.39 | 45.18 |
| | 2¼ | ... | ... | ... | ... | ... | ... | ... | ... | ... | 22.60 | 24.90 | 29.77 | 30.73 | 34.22 | 38.57 | 40.16 |
| | 2½ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 22.42 | 26.80 | 27.66 | 30.79 | 34.65 | 36.14 |
| | 2¾ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 24.36 | 25.15 | 27.99 | 31.55 | 32.86 |
| | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 23.05 | 25.66 | 28.93 | 30.12 |
| 44 | **1½** | ... | ... | ... | ... | ... | ... | **0.465** | **0.521** | **0.626** | **0.670** | **0.738** | **0.882** | **0.911** | **1.014** | **1.142** | **1.190** |
| | **1¾** | ... | ... | ... | ... | ... | ... | ... | **0.447** | **0.536** | **0.574** | **0.633** | **0.756** | **0.781** | **0.869** | **0.979** | **1.021** |
| | **2** | ... | ... | ... | ... | ... | ... | ... | ... | **0.469** | **0.502** | **0.553** | **0.661** | **0.683** | **0.761** | **0.857** | **0.893** |
| | **2¼** | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.447** | **0.492** | **0.588** | **0.608** | **0.676** | **0.762** | **0.794** |
| | **2½** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.443** | **0.529** | **0.546** | **0.608** | **0.686** | **0.714** |
| | **2¾** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.481** | **0.497** | **0.553** | **0.623** | **0.649** |
| | **3** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | **0.456** | **0.507** | **0.571** | **0.596** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1½ | | | | | | | 24.07 | 26.99 | 32.39 | 34.68 | 38.23 | 45.70 | 47.17 | 52.51 | 59.20 | 61.64 |
| | 1¾ | | | | | | | | 23.13 | 27.76 | 29.73 | 32.77 | 39.17 | 40.44 | 45.01 | 50.74 | 52.84 |
| | 2 | | | | | | | | | 24.29 | 26.01 | 28.67 | 34.27 | 35.38 | 39.38 | 44.40 | 46.23 |
| | 2¼ | | | | | | | | | | 23.13 | 25.49 | 30.47 | 31.45 | 35.01 | 39.46 | 41.10 |
| | 2½ | | | | | | | | | | | 22.94 | 27.42 | 28.30 | 31.50 | 35.52 | 36.99 |
| | 2¾ | | | | | | | | | | | | 24.93 | 25.73 | 28.64 | 32.29 | 33.62 |
| | 3 | | | | | | | | | | | | | 23.59 | 26.26 | 29.60 | 30.82 |
| 45 | **1½** | | | | | | | **0.454** | **0.509** | **0.612** | **0.655** | **0.721** | **0.863** | **0.891** | **0.992** | **1.118** | **1.163** |
| | **1¾** | | | | | | | | **0.437** | **0.525** | **0.561** | **0.618** | **0.739** | **0.764** | **0.850** | **0.958** | **0.998** |
| | **2** | | | | | | | | | **0.459** | **0.491** | **0.541** | **0.646** | **0.668** | **0.744** | **0.838** | **0.873** |
| | **2¼** | | | | | | | | | | | **0.481** | **0.575** | **0.594** | **0.661** | **0.745** | **0.776** |
| | **2½** | | | | | | | | | | | **0.433** | **0.517** | **0.535** | **0.595** | **0.671** | **0.699** |
| | **2¾** | | | | | | | | | | | | **0.471** | **0.486** | **0.541** | **0.610** | **0.635** |
| | **3** | | | | | | | | | | | | | | **0.496** | **0.559** | **0.582** |
| | 1½ | | | | | | | 24.62 | 27.61 | 33.13 | 35.47 | 39.10 | 46.74 | 48.24 | 53.70 | 60.54 | 63.04 |
| | 1¾ | | | | | | | | 23.66 | 28.39 | 30.40 | 33.51 | 40.06 | 41.36 | 46.03 | 51.89 | 54.04 |
| | 2 | | | | | | | | | 24.84 | 26.60 | 29.32 | 35.06 | 36.19 | 40.28 | 45.41 | 47.28 |
| | 2¼ | | | | | | | | | | | 26.06 | 31.16 | 32.17 | 35.80 | 40.36 | 42.03 |
| | 2½ | | | | | | | | | | | 23.46 | 28.04 | 28.95 | 32.22 | 36.32 | 37.83 |
| | 2¾ | | | | | | | | | | | | 25.49 | 26.32 | 29.29 | 33.02 | 34.39 |
| | 3 | | | | | | | | | | | | | | 26.85 | 30.27 | 31.52 |
| 46 | **1½** | | | | | | | | **0.498** | **0.599** | **0.641** | **0.706** | **0.844** | **0.872** | **0.971** | **1.093** | **1.138** |
| | **1¾** | | | | | | | | **0.427** | **0.513** | **0.549** | **0.605** | **0.723** | **0.748** | **0.832** | **0.938** | **0.977** |
| | **2** | | | | | | | | | **0.449** | **0.481** | **0.529** | **0.633** | **0.654** | **0.728** | **0.820** | **0.855** |
| | **2¼** | | | | | | | | | | | **0.470** | **0.562** | **0.581** | **0.647** | **0.728** | **0.759** |
| | **2½** | | | | | | | | | | | **0.423** | **0.506** | **0.523** | **0.582** | **0.656** | **0.683** |
| | **2¾** | | | | | | | | | | | | **0.460** | **0.476** | **0.529** | **0.596** | **0.621** |
| | **3** | | | | | | | | | | | | | | **0.485** | **0.547** | **0.560** |
| | 1½ | | | | | | | | 28.22 | 33.86 | 36.26 | 39.97 | 47.78 | 49.32 | 54.90 | 61.89 | 64.44 |
| | 1¾ | | | | | | | | 24.19 | 29.03 | 31.08 | 34.26 | 40.95 | 42.27 | 47.06 | 43.04 | 55.24 |
| | 2 | | | | | | | | | 25.40 | 27.19 | 29.97 | 35.83 | 36.99 | 41.17 | 46.41 | 48.33 |
| | 2¼ | | | | | | | | | | | 26.64 | 31.85 | 32.88 | 36.60 | 41.26 | 42.96 |
| | 2½ | | | | | | | | | | | 23.98 | 28.67 | 29.59 | 32.94 | 37.13 | 38.67 |
| | 2¾ | | | | | | | | | | | | 26.06 | 26.90 | 29.94 | 33.76 | 35.15 |
| | 3 | | | | | | | | | | | | | | 27.45 | 30.94 | 32.22 |
| 47 | **1½** | | | | | | | | **0.488** | **0.586** | **0.627** | **0.690** | **0.826** | **0.853** | **0.950** | **1.069** | **1.113** |
| | **1¾** | | | | | | | | **0.418** | **0.502** | **0.538** | **0.592** | **0.708** | **0.731** | **0.814** | **0.917** | **0.956** |
| | **2** | | | | | | | | | **0.439** | **0.470** | **0.518** | **0.619** | **0.640** | **0.712** | **0.802** | **0.836** |
| | **2¼** | | | | | | | | | | | **0.460** | **0.551** | **0.568** | **0.633** | **0.713** | **0.743** |
| | **2½** | | | | | | | | | | | | **0.496** | **0.512** | **0.569** | **0.642** | **0.669** |
| | **2¾** | | | | | | | | | | | | | **0.466** | **0.518** | **0.583** | **0.608** |
| | **3** | | | | | | | | | | | | | | **0.475** | **0.535** | **0.557** |

# COLUMN SPIRALS
# PERCENTAGE OF VOLUME OF CORE
# AND
# WEIGHT IN POUNDS PER FOOT OF COLUMN

HEAVY TYPE GIVES PERCENTAGES
LIGHT TYPE GIVES WEIGHTS

WEIGHTS DO NOT INCLUDE SPACERS
WIRE SIZES ARE A. S. & W. CO. GAGE

| Size of wire....... | | #4 | #3 | ¼″ | #2 | #1 | #0 | 5⁄16″ | #2/0 | #3/0 | ⅜″ | #4/0 | #5/0 | 7⁄16″ | #6/0 | #7/0 | ½″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter (inches). | | 0.2253 | 0.2437 | 0.2500 | 0.2625 | 0.2830 | 0.3065 | 0.3125 | 0.3310 | 0.3625 | 0.3750 | 0.3938 | 0.4305 | 0.4375 | 0.4615 | 0.4900 | 0.5000 |
| Area (sq. in.)..... | | 0.0399 | 0.0466 | 0.0491 | 0.0541 | 0.0629 | 0.0738 | 0.0767 | 0.0860 | 0.1032 | 0.1105 | 0.1218 | 0.1456 | 0.1503 | 0.1673 | 0.1886 | 0.1964 |
| Diam. of core (in.) | Pitch of spiral (in.) | | | | | | | | | | | | | | | | |
| 47 | 1½ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 28.83 | 34.60 | 37.05 | 40.84 | 48.82 | 50.39 | 56.09 | 63.23 | 65.85 |
| | 1¾ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 24.72 | 29.66 | 31.76 | 35.00 | 41.84 | 43.20 | 48.08 | 54.20 | 56.44 |
| | 2 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 25.95 | 27.79 | 30.63 | 36.61 | 37.79 | 42.07 | 47.42 | 49.39 |
| | 2¼ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 27.22 | 32.54 | 33.59 | 37.39 | 42.16 | 43.90 |
| | 2½ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 29.29 | 30.24 | 33.66 | 37.94 | 39.51 |
| | 2¾ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 27.49 | 30.60 | 34.49 | 35.92 |
| | 3 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 28.04 | 31.61 | 32.92 |
| 48 | **1½** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **0.477** | **0.573** | **0.614** | **0.676** | **0.809** | **0.836** | **0.930** | **1.037** | **1.091** |
| | **1¾** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **0.491** | **0.526** | **0.580** | **0.693** | **0.716** | **0.797** | **0.898** | **0.936** |
| | **2** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **0.460** | **0.507** | **0.606** | **0.627** | **0.697** | **0.786** | **0.818** |
| | **2¼** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **0.451** | **0.539** | **0.557** | **0.620** | **0.698** | **0.728** |
| | **2½** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **0.485** | **0.501** | **0.558** | **0.629** | **0.655** |
| | **2¾** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **0.456** | **0.507** | **0.571** | **0.596** |
| | **3** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **0.465** | **0.524** | **0.546** |
| | 1½ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 29.44 | 35.34 | 37.84 | 41.71 | 49.85 | 51.46 | 57.28 | 64.58 | 67.25 |
| | 1¾ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 30.29 | 32.43 | 35.75 | 42.73 | 44.11 | 49.10 | 55.35 | 57.64 |
| | 2 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 28.38 | 31.28 | 37.39 | 38.60 | 42.96 | 48.43 | 50.44 |
| | 2¼ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 27.80 | 33.24 | 34.31 | 38.19 | 43.05 | 44.83 |
| | 2½ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 29.91 | 30.88 | 34.37 | 38.74 | 40.35 |
| | 2¾ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 28.07 | 31.24 | 35.22 | 36.68 |
| | 3 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 28.64 | 32.29 | 33.62 |

## COLUMN SPIRALS
## JOINT COMMITTEE RECOMMENDATIONS

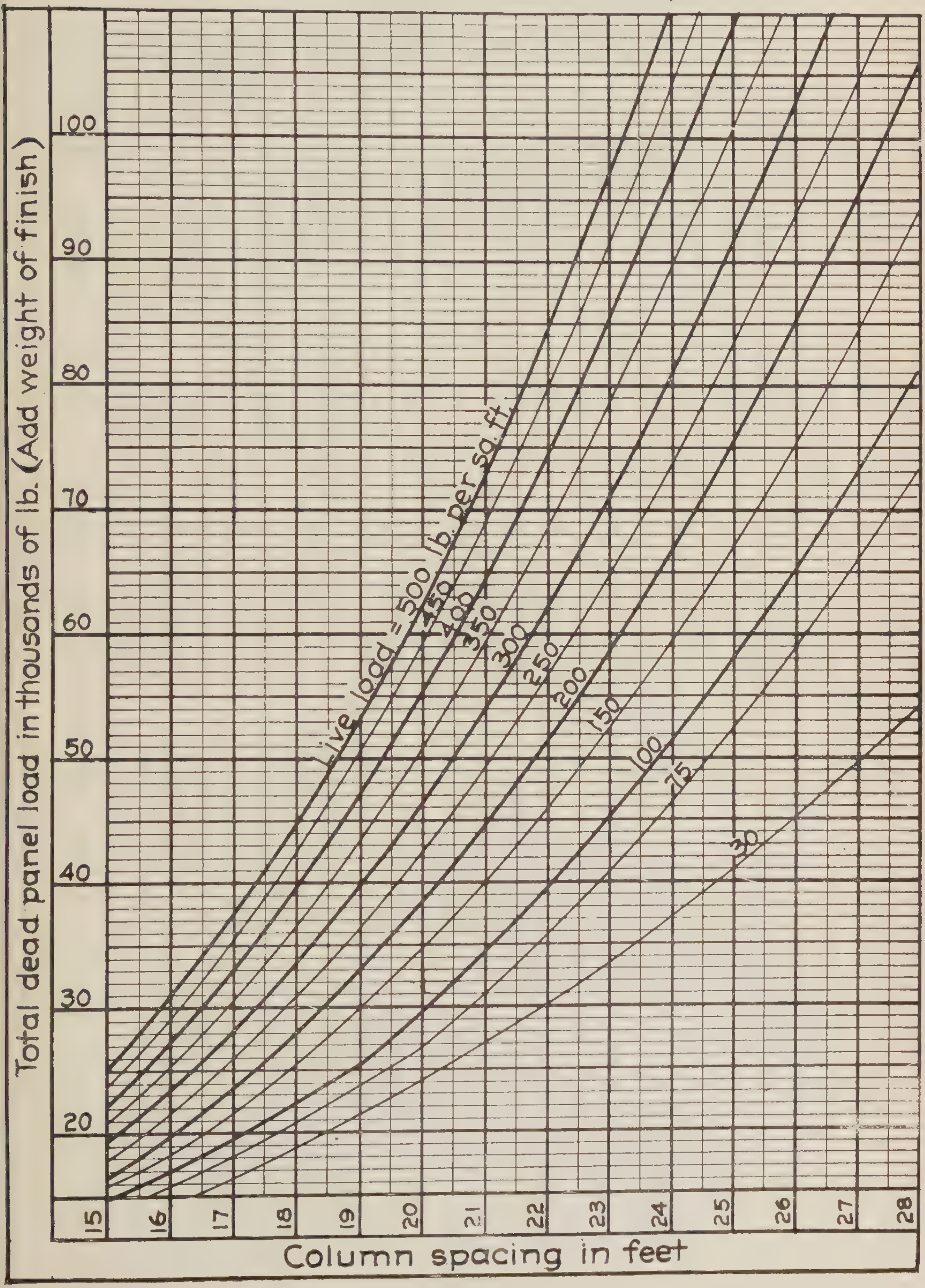
***Volume of spiral equal to 1% of volume of core*** ***Maximum pitch*** $= \frac{d}{6}$ ***or 2½ in.***

| Diam. of core (inches) | Am. S. & W. Co.'s gage | | Rod sizes | |
|---|---|---|---|---|
| | Size (No.) | Pitch (inches) | Size (inches) | Pitch (inches) |
| 8 | 6 | 1¼ | | |
| 9 | 5 | 1½ | | |
| 10 | 4 | 1½ | | |
| 11 | 3 | 1⅝ | ¼ | 1¾ |
| 12 | 2 | 1¾ | ¼ | 1⅝ |
| 13 | 1 | 1¾ | ¼ | 1½ |
| 14 | 1 | 1¾ | 5/16 | 2⅛ |
| 15 | 0 | 1⅞ | 5/16 | 2 |
| 16 | 2/0 | 2⅛ | 5/16 | 1⅞ |
| 17 | 2/0 | 2 | ⅜ | 2½ |
| 18 | 3/0 | 2¼ | ⅜ | 2⅜ |
| 19 | 3/0 | 2⅛ | ⅜ | 2¼ |
| 20 | 3/0 | 2 | ⅜ | 2⅛ |
| 21 | 4/0 | 2¼ | ⅜ | 2 |
| 22 | 4/0 | 2⅛ | 7/16 | 2¾ |
| 23 | 4/0 | 2⅛ | 7/16 | 2⅝ |
| 24 | 4/0 | 2 | 7/16 | 2½ |
| 25 | 5/0 | 2¼ | 7/16 | 2⅜ |
| 26 | 5/0 | 2¼ | 7/16 | 2¼ |
| 27 | 5/0 | 2⅛ | 7/16 | 2⅛ |
| 28 | 5/0 | 2 | 7/16 | 2⅛ |
| 29 | 6/0 | 2¼ | 7/16 | 2 |
| 30 | 6/0 | 2¼ | 7/16 | 2 |
| 31 | 6/0 | 2⅛ | ½ | 2½ |
| 32 | 6/0 | 2 | ½ | 2⅜ |
| 33 | 7/0 | 2¼ | ½ | 2⅜ |
| 34 | 7/0 | 2⅛ | ½ | 2¼ |
| 35 | 7/0 | 2⅛ | ½ | 2¼ |
| 36 | 7/0 | 2 | ½ | 2⅛ |
| 37 | 7/0 | 2 | ½ | 2⅛ |
| 38 | 7/0 | 2 | ½ | 2 |
| 39 | 7/0 | 1⅞ | ½ | 2 |
| 40 | 7/0 | 1⅞ | ½ | 1⅞ |
| 41 | 7/0 | 1¾ | ½ | 1⅞ |
| 42 | 7/0 | 1¾ | ½ | 1⅞ |
| 43 | 7/0 | 1¾ | ½ | 1¾ |
| 44 | 7/0 | 1⅝ | ½ | 1¾ |
| 45 | 7/0 | 1⅝ | ½ | 1¾ |
| 46 | 7/0 | 1⅝ | ½ | 1⅝ |
| 47 | 7/0 | 1½ | ½ | 1⅝ |
| 48 | 7/0 | 1½ | ½ | 1⅝ |
| 49 | 7/0 | 1½ | ½ | 1½ |
| 50 | 7/0 | 1½ | ½ | 1½ |

## AMERICAN STEEL & WIRE CO.'S STEEL WIRE GAGE

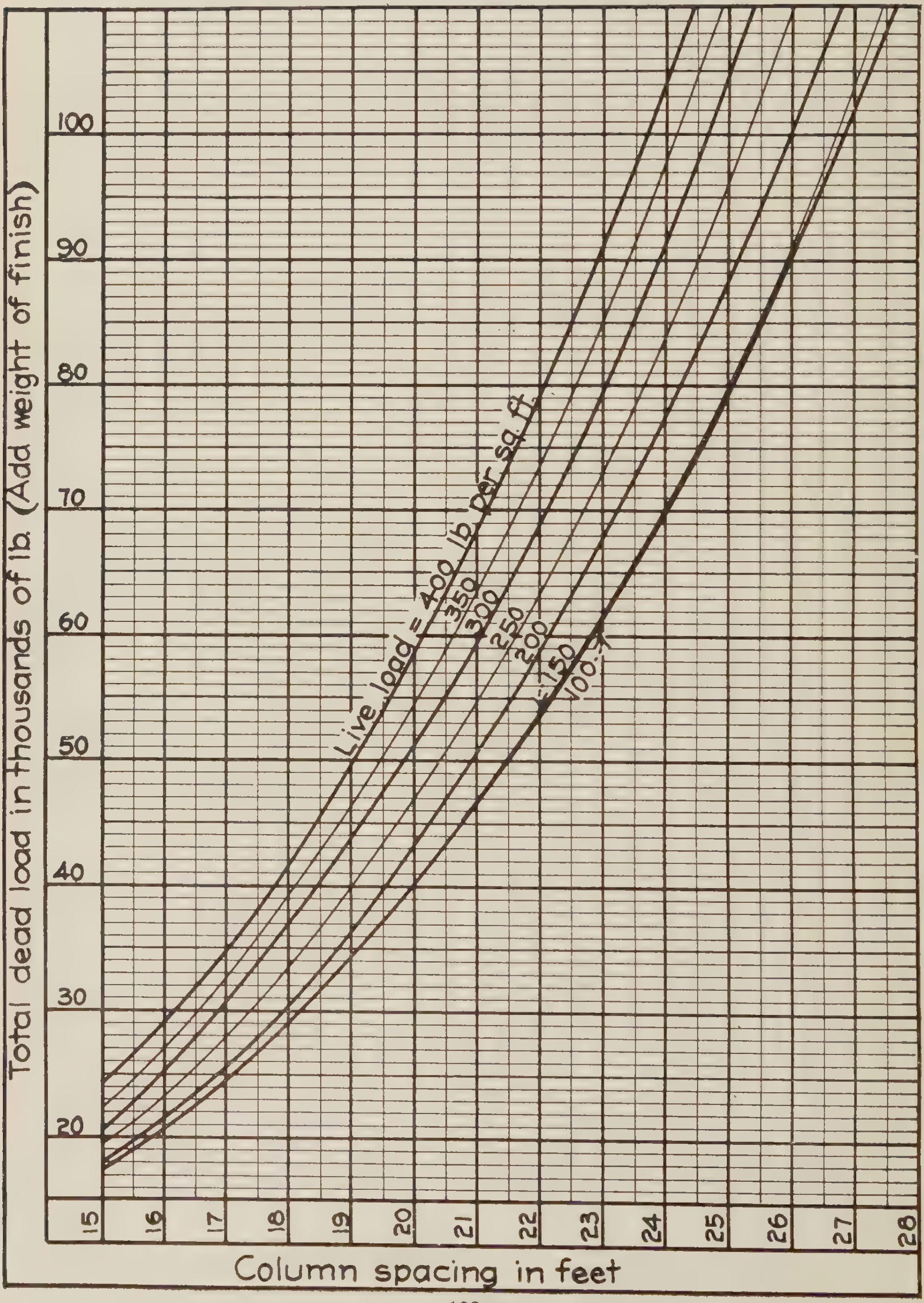
| Diameter (inches) | Steel wire gage | Diameter (inches) | Area, square inches | Pounds per foot | Pounds per mile | Feet per pound |
|---|---|---|---|---|---|---|
| ½ | | 0.5000 | 0.19635 | 0.6668 | 3,521.0 | 1.500 |
| | 7/0 | 0.4900 | 0.18857 | 0.6404 | 3,381.0 | 1.562 |
| 15/32 | | 0.46875 | 0.17257 | 0.5861 | 3,094.0 | 1.706 |
| | 6/0 | 0.4615 | 0.16728 | 0.5681 | 2,999.0 | 1.760 |
| 7/16 | | 0.4375 | 0.15033 | 0.5105 | 2,696.0 | 1.959 |
| | 5/0 | 0.4305 | 0.14556 | 0.4943 | 2,610.0 | 2.023 |
| 13/32 | | 0.40625 | 0.12962 | 0.4402 | 2,324.0 | 2.272 |
| | 4/0 | 0.3938 | 0.12180 | 0.4136 | 2,184.0 | 2.418 |
| ⅜ | | 0.3750 | 0.11045 | 0.3751 | 1,980.0 | 2.666 |
| | 3/0 | 0.3625 | 0.10321 | 0.3505 | 1,851.0 | 2.853 |
| 11/32 | | 0.34375 | 0.092806 | 0.3152 | 1,664.0 | 3.173 |
| | 2/0 | 0.3310 | 0.086049 | 0.2922 | 1,543.0 | 3.422 |
| 5/16 | | 0.3125 | 0.076699 | 0.2605 | 1,375.0 | 3.839 |
| | 0 | 0.3065 | 0.073782 | 0.2506 | 1,323.0 | 3.991 |
| | 1 | 0.2830 | 0.062902 | 0.2136 | 1,128.0 | 4.681 |
| 9/32 | | 0.28125 | 0.062126 | 0.2110 | 1,114.0 | 4.74 |
| | 2 | 0.2625 | 0.054119 | 0.1838 | 970.4 | 5.441 |
| ¼ | | 0.2500 | 0.049087 | 0.1667 | 880.2 | 5.999 |
| | 3 | 0.2437 | 0.046645 | 0.1584 | 836.4 | 6.313 |
| | 4 | 0.2253 | 0.039867 | 0.1354 | 714.8 | 7.386 |
| 7/32 | | 0.21875 | 0.037583 | 0.1276 | 673.9 | 7.835 |
| | 5 | 0.2070 | 0.033654 | 0.1143 | 603.4 | 8.750 |
| | 6 | 0.1920 | 0.028953 | 0.09832 | 519.2 | 10.17 |
| 3/16 | | 0.1875 | 0.027612 | 0.09377 | 495.1 | 10.66 |
| | 7 | 0.1770 | 0.024606 | 0.08356 | 441.2 | 11.97 |
| | 8 | 0.1620 | 0.020612 | 0.07000 | 369.6 | 14.29 |
| 5/32 | | 0.15625 | 0.019175 | 0.06512 | 343.8 | 15.36 |
| | 9 | 0.1483 | 0.017273 | 0.05866 | 309.7 | 17.05 |
| | 10 | 0.1350 | 0.014314 | 0.04861 | 356.7 | 20.57 |
| ⅛ | | 0.125 | 0.012272 | 0.04168 | 220.0 | 24.00 |
| | 11 | 0.1205 | 0.011404 | 0.03873 | 204.5 | 25.82 |
| | 12 | 0.1055 | 0.0087417 | 0.02969 | 156.7 | 33.69 |
| 3/32 | | 0.09375 | 0.0069029 | 0.02344 | 123.8 | 42.66 |
| | 13 | 0.0915 | 0.0065755 | 0.02233 | 117.9 | 44.78 |
| | 14 | 0.0800 | 0.0050266 | 0.01707 | 90.13 | 58.58 |
| | 15 | 0.0720 | 0.0040715 | 0.01383 | 73.01 | 72.32 |
| | 16 | 0.0625 | 0.0030680 | 0.01042 | 55.01 | 95.98 |
| | 17 | 0.0540 | 0.0022902 | 0.007778 | 41.07 | 128.60 |

## WEIGHT OF TYPICAL SQUARE PANEL OF THREE-BEAM-AND-GIRDER FLOOR SYSTEM DESIGNED IN ACCORDANCE WITH JOINT COMMITTEE RECOMMENDATIONS
## (FOR ESTIMATING COLUMN LOADS)



COLUMNS

## WEIGHT OF TYPICAL FLOOR PANEL OF FLAT SLAB CONSTRUCTION DESIGNED IN ACCORDANCE WITH CHICAGO BUILDING CODE (FOR ESTIMATING COLUMN LOADS)



# SECTION 8

## BENDING AND DIRECT STRESS

### Rectangular Sections

The following notation is used:

$R$ = resultant thrust.
$N$ = vertical component of $R$.
$x_o$ = eccentricity of thrust.
$t$ = thickness or depth of section.
$b$ = breadth of section.
$d'$ = embedment of steel—top and bottom.
$A_s$ = area of steel on tension side.
$A'$ = area of steel on compression side.
$A_o$ = total area of steel = $A_s + A'$.
$p_o$ = total percentage of steel = $\frac{A_o}{bd}$.
$f_c$ = maximum unit compression in concrete.
$f_s$ = maximum unit tension in steel.
$f_s'$ = maximum unit compression in steel.

**Case I.—Compression Over Whole Section** ($A' = A_s$).

$$f_c = \frac{NK}{bt} \tag{1}$$

Diagrams 44 to 49 inclusive give values of $K$ for various values of $p_o$, $\frac{x_o}{t}$, and $\frac{d'}{t}$, and for both $n = 12$ and $n = 15$. For values of $\frac{x_o}{t}$ beyond the termination of the curves, tension occurs over part of the section and the diagrams for Case II should be used.

**Case II.—Tension Over Part of Section** ($A' = A_s$).

$$M = f_c bt^2 \left[ \frac{np_o r^2}{kt^2} + \frac{k}{12}(3 - 2k) \right]$$

or

$$f_c = \frac{M}{Lbt^2} \tag{2}$$

Diagrams 50, 51, 52, 54, 55 and 56 give values of $k$ for various values of $p_o$, $\frac{x_o}{t}$, and $\frac{d'}{t}$, and for both $n = 12$ and $n = 15$. Diagrams 53 and 57 give values of $L$.

The method of procedure in solving problems is as follows: (1) Determine $k$ from the proper diagram; (2) find $L$ from Diagram 53 or 57; (3) solve equation (2) for $f_c$; (4) find unit stresses in the steel from the formulas

$$f_s = nf_c \left( \frac{d}{kt} - 1 \right) \tag{3}$$

$$f_s' = nf_c \left( 1 - \frac{d'}{kt} \right) \tag{4}$$

**Case III.**—**Tension Over Part of Section** $(A' = 0)$. Notation is given on Diagrams 58 and 59.

$$k^2 - 2pn(1 - k) = k^2 j \frac{d}{e'} \qquad (5)$$

$$j = 1 - \tfrac{1}{3}k \qquad (6)$$

$$p = \frac{k^2}{2n(1 - k)}\left[1 - j\frac{d}{e'}\right] \qquad (7)$$

$$K = \frac{M_c}{bd^2} = \frac{Ne'}{bd^2} = \tfrac{1}{2}f_c kj \qquad (8)$$

$$f_c = \frac{2Ne'}{kjbd^2} \qquad (9)$$

$$f_s = nf_c\frac{1 - k}{k} \qquad (10)$$

Diagrams 58 and 59 may be used as shown in two of the examples which follow.

### Examples for Rectangular Sections

*A beam is* 9 *in. wide and* 20 *in. deep. The reinforcement both above and below consists of one steel rod* 1 *in. in diameter embedded at a depth of* 2 *in. At a certain section, the normal component of the resultant force is* 60,000 *lb., acting at a distance of* 3.4 *in. from the gravity axis. Assume* $n = 15$. *Compute the maximum unit compressive stress in the concrete.*

$$p_o = \frac{A_o}{bt} = \frac{(2)(0.7854)}{(9)(20)} = 0.0087$$

$$\frac{x_o}{t} = \frac{3.4}{20} = 0.17$$

$$d' = 0.10t$$

For these values of $p_o$ and $\frac{x_o}{t}$, Diagram 48 gives $K = 1.70$ and shows that the problem falls under Case I. Then by formula (1)

$$f_c = \frac{NK}{bt} = \frac{(60{,}000)(1.70)}{(9)(20)} = 567 \text{ lb. per sq. in.}$$

*Change the eccentricity of the preceding problem to* 6 *in. and solve.*

$$\frac{x_o}{t} = \frac{6}{20} = 0.30$$

For $p_o = 0.0087$ and $\frac{x_o}{t} = 0.30$, Diagram 48 shows that $\frac{x_o}{t}$ is too great for the problem to come under Case I. The method of procedure for Case II must then be followed.

Diagram 55 gives $k = 0.73$ for the values of $p_o$ and $\frac{x_o}{t}$ given above. With $k = 0.73$ and $p_o = 0.0087$, Diagram 57 shows $L$ to be 0.123. Solving equation (2)

$$f_c = \frac{M}{Lbt^2} = \frac{(60{,}000)(6)}{(0.123)(9)(20)^2} = 815 \text{ lb. per sq. in.}$$

Using formula (3)

$$f_s = nf_c\left(\frac{d}{kt} - 1\right) = (15)(815)\left(\frac{18}{0.73 \times 20} - 1\right) = 2830 \text{ lb. per sq. in.}$$

The stress $f_s'$ may be found by formula (4) but is always less than $n \times f_c$.

*An arch is* 20 *in. deep and is reinforced with three rods* ¾ *in. in diameter to each foot of width, both above and below. If the rods are embedded to a depth of* 2 *in. and the normal component of the resultant thrust on a section is* 100,000 *lb. for* 1-*ft. width of arch,* *with an eccentricity of 3.4 in., determine the maximum intensity of compressive stress on the concrete. Assume $n = 15$.*

$$p_o = \frac{(6)(0.4418)}{(12)(20)} = 0.0110$$

$$\frac{x_o}{t} = \frac{3.4}{20} = 0.170$$

Diagram 48 gives $K = 1.63$ and the problem comes under Case I. Then by formula (1)

$$f_c = \frac{NK}{bt} = \frac{(100{,}000)(1.63)}{(12)(20)} = 679 \text{ lb. per sq. in.}$$

*The vertical wall of a cantilever retaining wall is subjected to an earth pressure of 2400 lb. applied at a distance of 4.54 ft. above the top of footing. The weight of vertical wall is 2200 lb. which can be considered as applied 5 in. in front of the steel. Determine the unit stresses $f_c$ and $f_s$, assuming $n = 15$, $p = 0.0077$ and $d = 10.5$ in.*

The moment at the top of footing

$$M = (2400)(4.54)(12) + (2200)(5) = 141{,}700 \text{ in.} - \text{lb.}$$

$$K = \frac{141{,}700}{(12)(10.5)^2} = 107$$

$$\frac{e'}{d} = \frac{141{,}700}{(2200)(10.5)} = 6.1$$

Entering Diagram 59 with a value of $p = 0.0077$ on the lower right-hand margin and tracing vertically to a value of $\frac{e'}{d} = 6.1$, then horizontally to the left to a point vertically above $K = 107$, we find $f_s = 14{,}000$ and $f_c = 610$.

*Design the vertical wall of the retaining wall described in the preceding problem so that $f_c = 750$ and $f_s = 16{,}000$. Assume the weight of wall to be 2000 lb.*

For these unit stresses the left-hand part of Diagram 59 shows $K = 133.8$. Then

$$d = \sqrt{\frac{141{,}700}{(133.8)(12)}} = 9.4 \text{ in., say } 9\tfrac{1}{2} \text{ in.}$$

$$\frac{e'}{d} = \frac{141{,}700}{(2000)(9.5)} = 7.45$$

Following across the diagram horizontally to the right to a value of $\frac{e'}{d} = 7.45$ and then vertically downward to the lower right-hand margin, we find $p = 0.0085$.

## Round Columns

Concrete outside of the hooping is neglected. The following notation is used:

$P$ = direct load (compression).
$e$ = eccentricity of load.
$r$ = radius of column core.
$p$ = total percentage of steel.
$f_c$ = maximum unit compression in concrete.
$f_c'$ = minimum unit compression in concrete.
$f_s$ = maximum unit tension in steel.
$f_s'$ = maximum unit compression in steel.

**Case I.—Compression Over Whole Section.**—Diagram 60 gives values of $\frac{\pi r^2 f_c}{P}$ for various values of $p$ and $\frac{e}{r}$, and for both $n = 12$ and $n = 15$.

**Case II.—Tension Over Part of Section.**

$$\frac{R}{f_c} = \frac{Pe}{\pi r^3 f_c} \qquad (11)$$

$$\frac{f_s}{R} = \frac{\pi r^3 f_s}{Pe} \qquad (12)$$

The right-hand side of Diagrams 61 and 62 gives values of $\frac{R}{f_c}$ in formula (11) for various values of $p$ and $\frac{r}{e}$, and the left-hand side of these diagrams gives values of $\frac{f_s}{R}$ in formula (12).

**Case III.—Bending Only.**

$$\frac{R}{f_c} = \frac{M}{\pi r^3 f_c} \qquad (13)$$

$$\frac{R}{f_s} = \frac{M}{\pi r^3 f_s} \qquad (14)$$

Values of $\frac{R}{f_c}$ and $\frac{R}{f_s}$ in the preceding equations are given in Diagram 63. Diagram 64 gives the concrete and steel stresses in solid circular sections in the same manner as the familiar diagrams for rectangular sections with steel in tension side only. In the present case the value of $\frac{M}{\pi r^3}$ is used instead of $\frac{M}{bd^2}$.

### Examples for Round Columns

*Assuming a column with 20-in. core reinforced with ten 1-in. square rods and sustaining a load of 200,000 lb. applied 2 in. off center, determine the maximum unit stress in the concrete, n = 15.*

$$r = 10 \text{ in.} \qquad p = \frac{10}{(3.1416)(10)^2} = 0.0318 \qquad \frac{e}{r} = \frac{2}{10} = 0.20$$

From Diagram 60

$$\frac{\pi r^2 f_c}{P} = 1.12$$

or

$$f_c = \frac{1.12P}{\pi r^2} = \frac{224{,}000}{314.16} = 712 \text{ lb. per sq. in.}$$

*Find the maximum unit stresses in the concrete and steel of the column in the preceding problem if the eccentricity of the load is 8 in.*

$$r = 10 \text{ in.} \qquad p = 0.0318 \qquad \frac{r}{e} = \frac{10}{8} = 1.25$$

From Diagram 62

$$\frac{R}{f_c} = 0.325 \qquad \frac{f_s}{R} = 25$$

$$R = \frac{Pe}{\pi r^3} = \frac{1{,}600{,}000}{3141.6} = 509$$

$$f_c = \frac{R}{0.325} = \frac{509}{0.325} = 1{,}566 \text{ lb. per sq. in.}$$

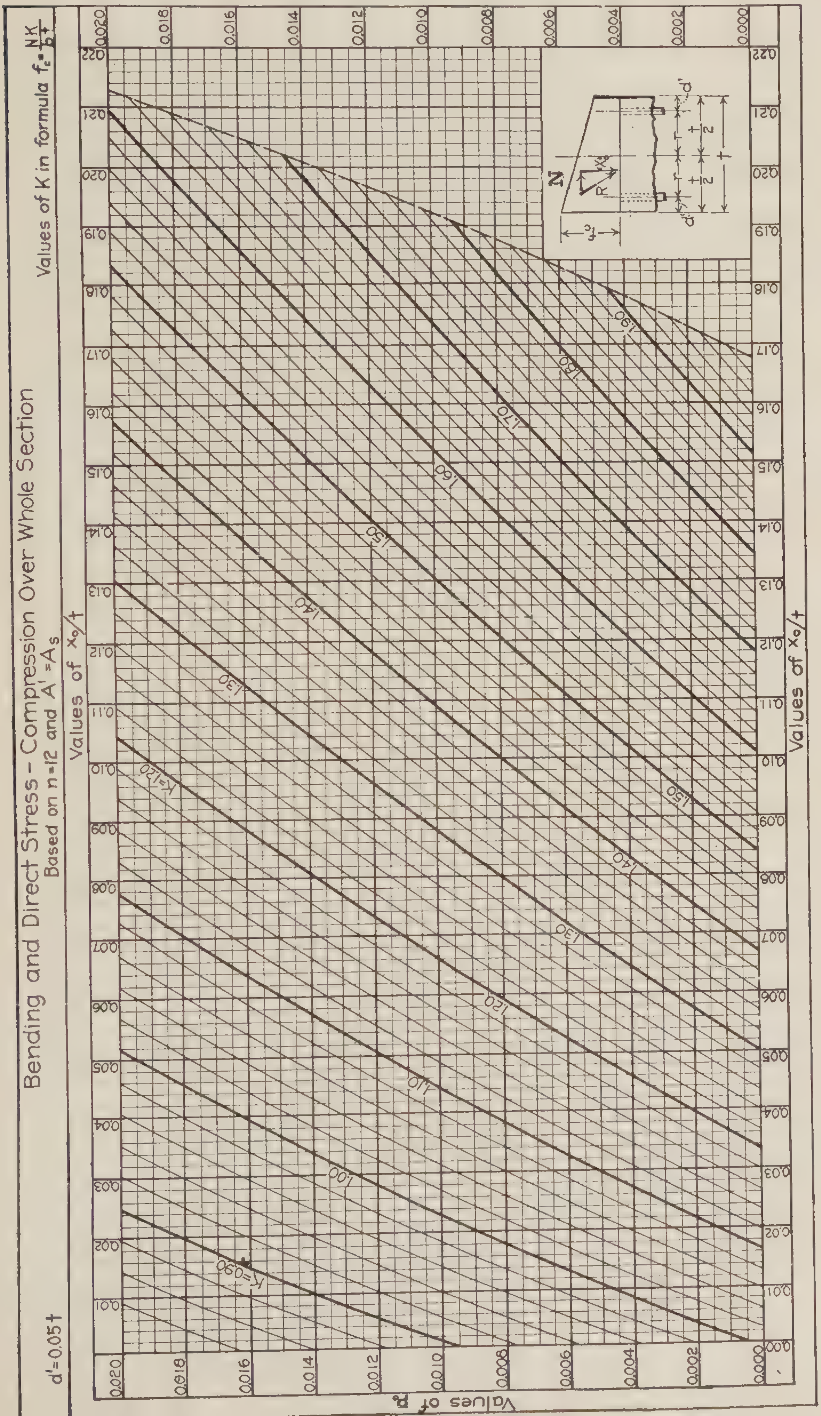
$$f_s = 25R = (25)(509) = 12{,}720 \text{ lb. per sq. in.}$$

$$f_s' = nf_c = 23{,}500 \text{ lb. per sq. in.}$$

## RECTANGULAR SECTIONS—COMPRESSION OVER WHOLE SECTION

VALUES OF $\frac{btf_c}{N}$

$d' = 0.05t$
$n = 12$
$A' = A_s$

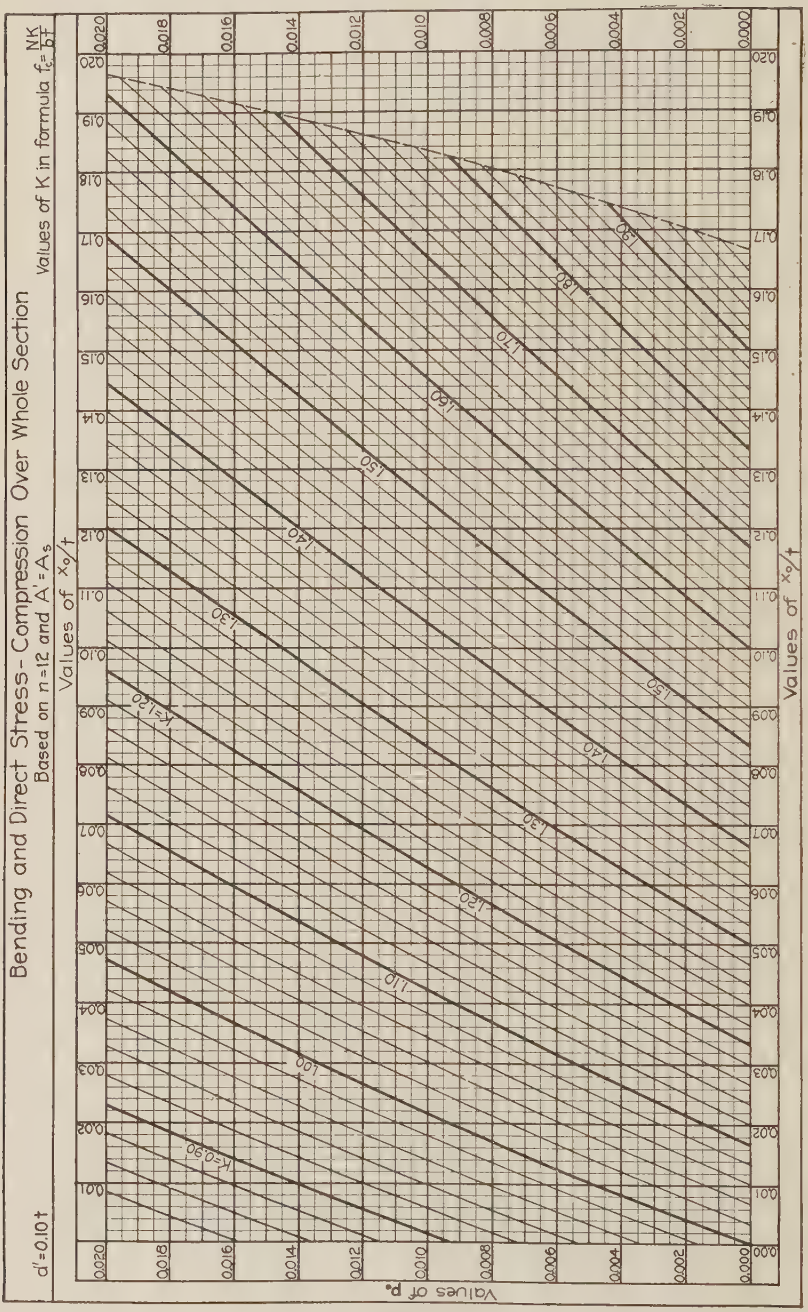


**BENDING AND DIRECT STRESS**

## RECTANGULAR SECTIONS—COMPRESSION OVER WHOLE SECTION

$d' = 0.10t$
$n = 12$
$A' = A_s$

### VALUES OF $\frac{btf_c}{N}$

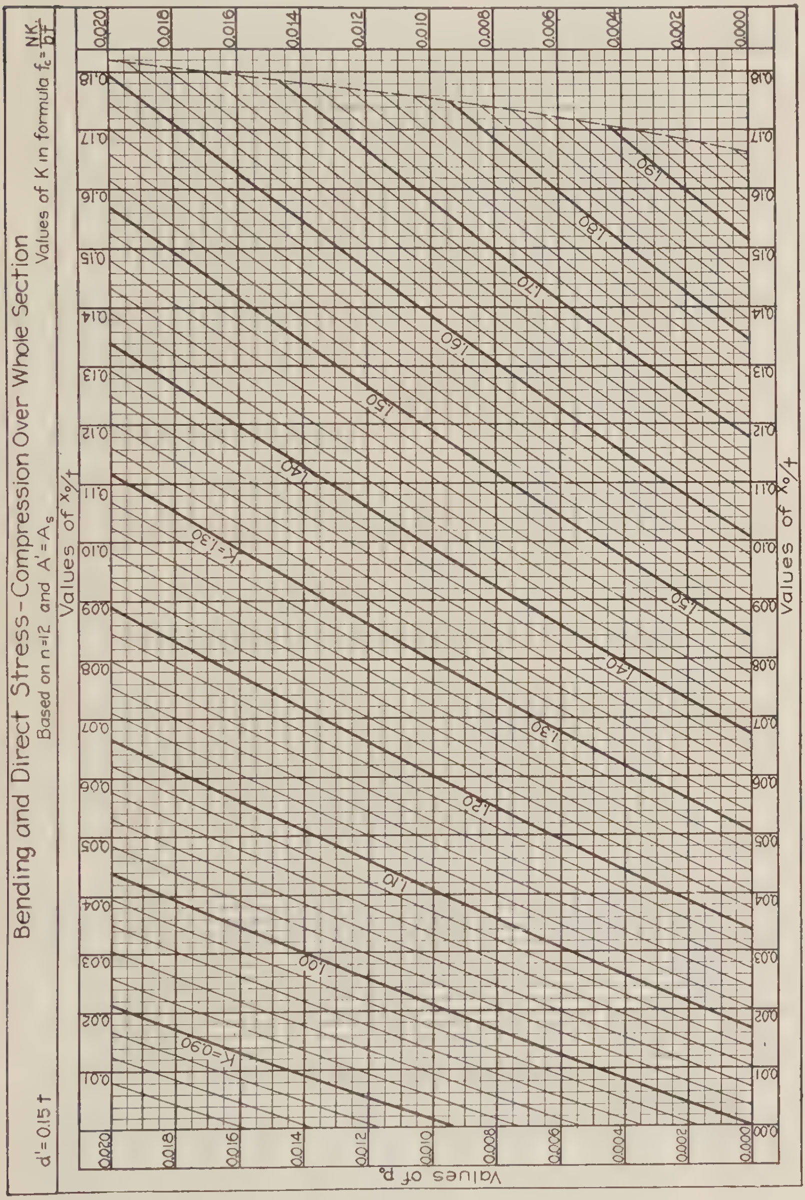


**BENDING
AND
DIRECT STRESS**

## RECTANGULAR SECTIONS—COMPRESSION OVER WHOLE SECTION

*VALUES OF* $\frac{btf_c}{N}$

$d' = 0.15t$
$n = 12$
$A' = A_s$

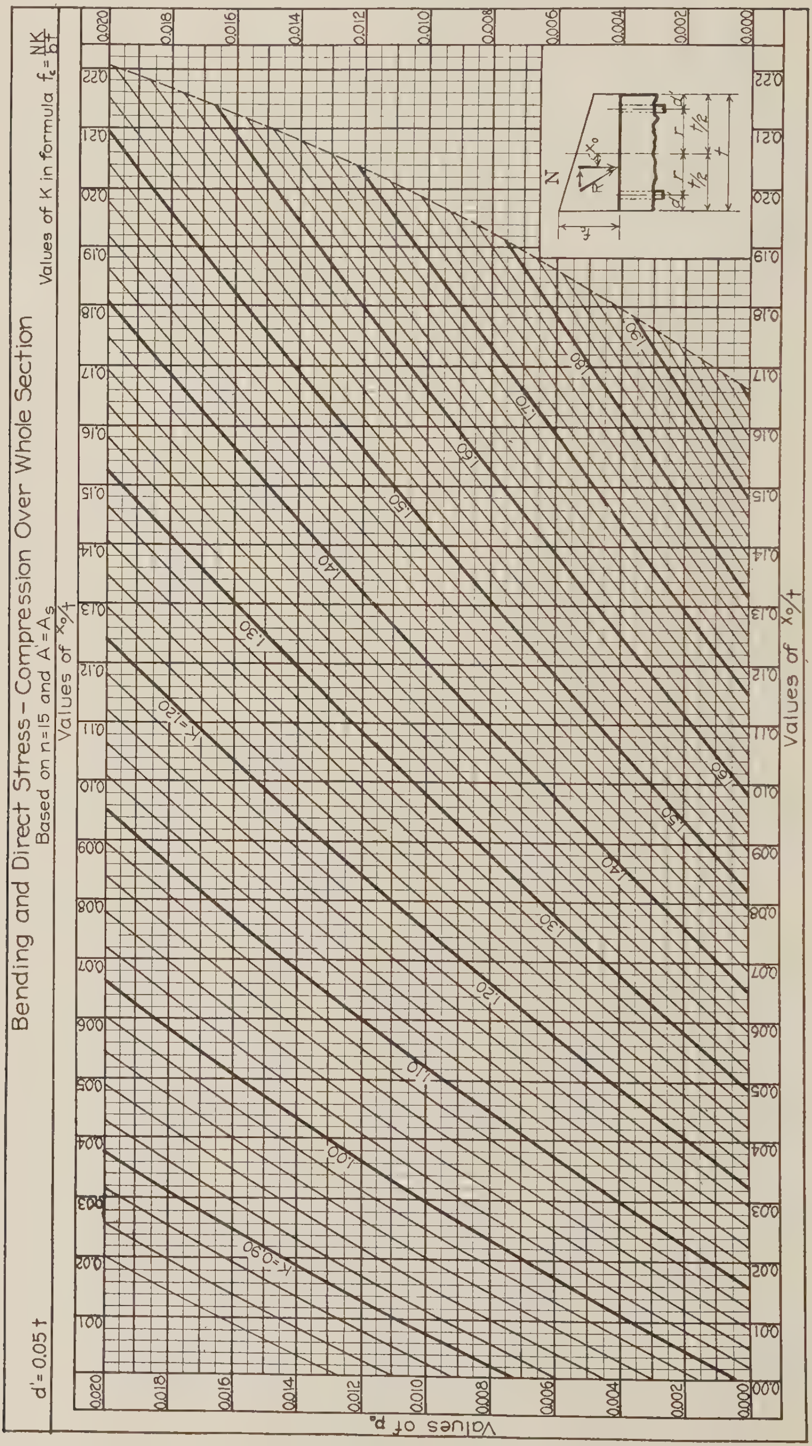


**BENDING AND DIRECT STRESS**

## RECTANGULAR SECTIONS—COMPRESSION OVER WHOLE SECTION

$d' = 0.05t$
$n = 15$
$A' = A_s$

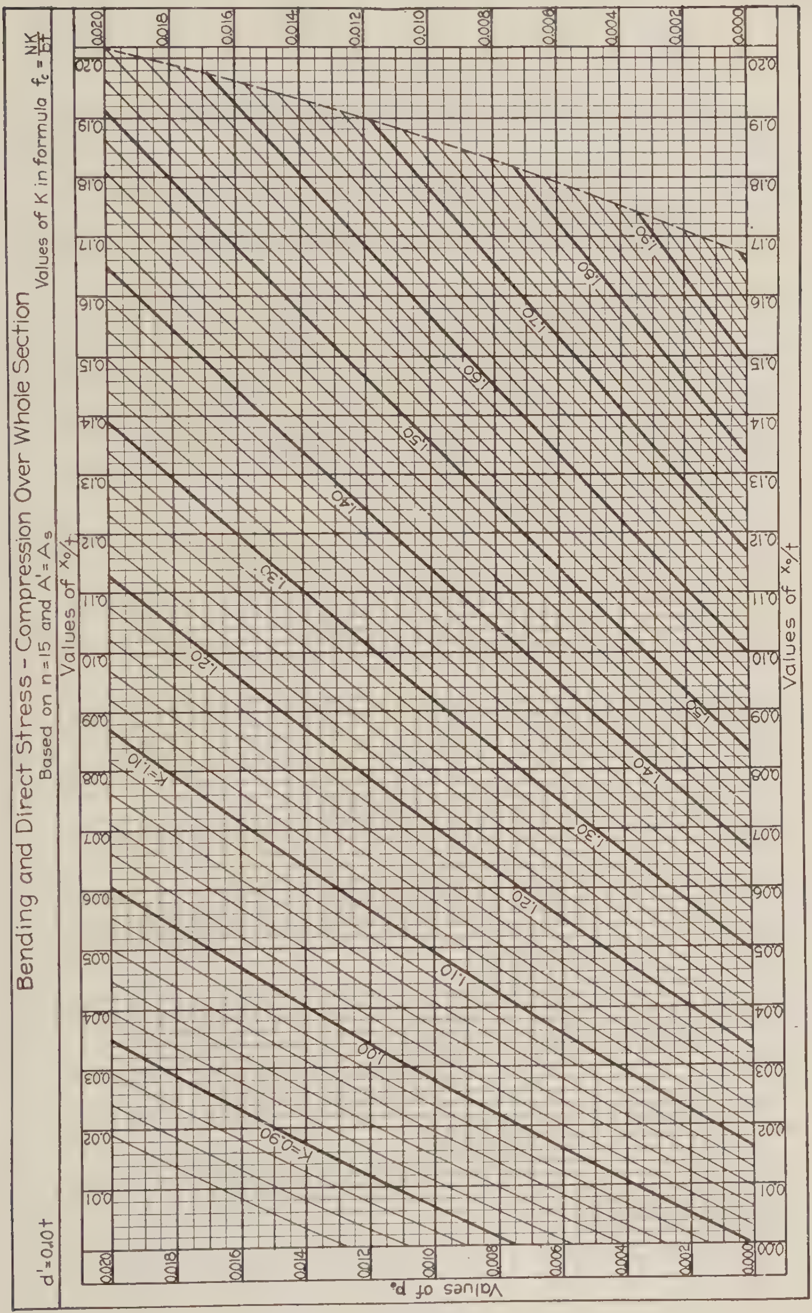
### VALUES OF $\frac{btf_c}{N}$



## RECTANGULAR SECTIONS—COMPRESSION OVER WHOLE SECTION

### VALUES OF $\frac{btf_c}{N}$

$d' = 0.10t$
$n = 15$
$A' = A_s$



**BENDING**
**AND**
**DIRECT STRESS**

## RECTANGULAR SECTIONS—COMPRESSION OVER WHOLE SECTION

$d' = 0.15t$
$n = 15$
$A' = A_s$

*VALUES OF* $\dfrac{btf_c}{N}$

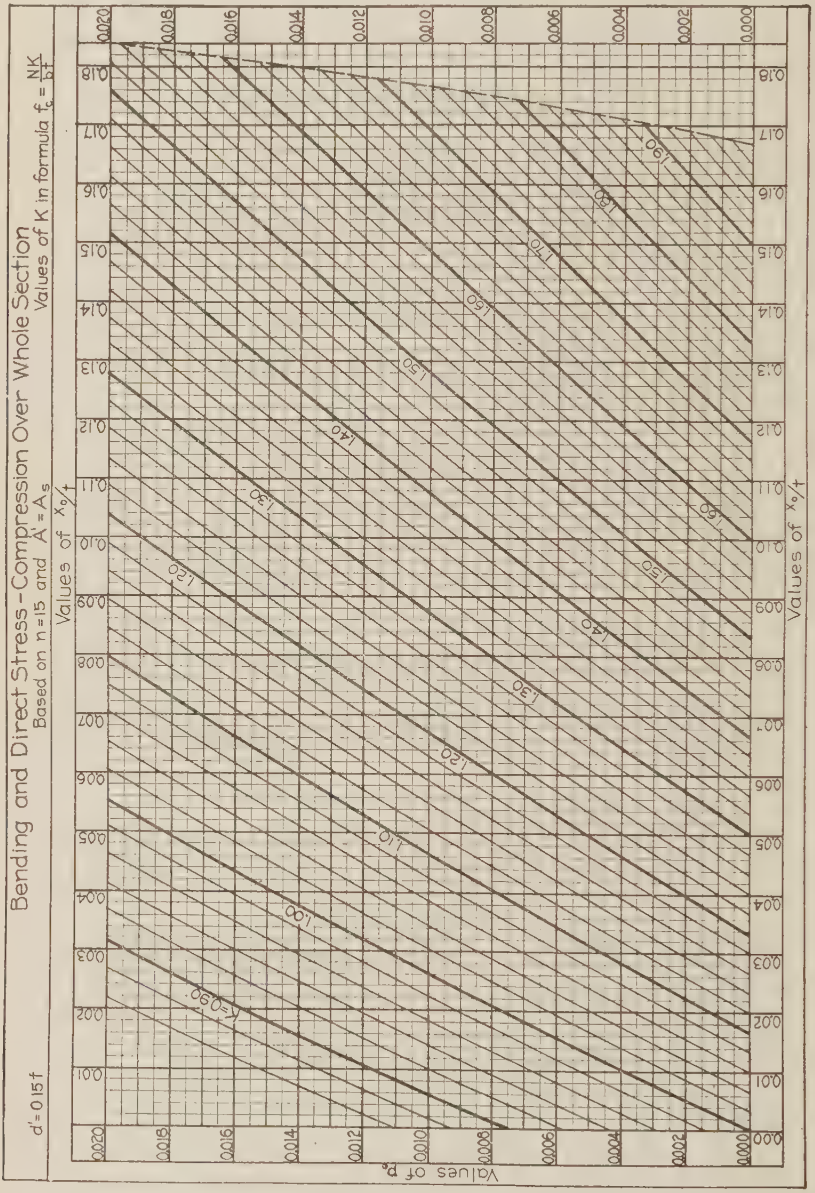


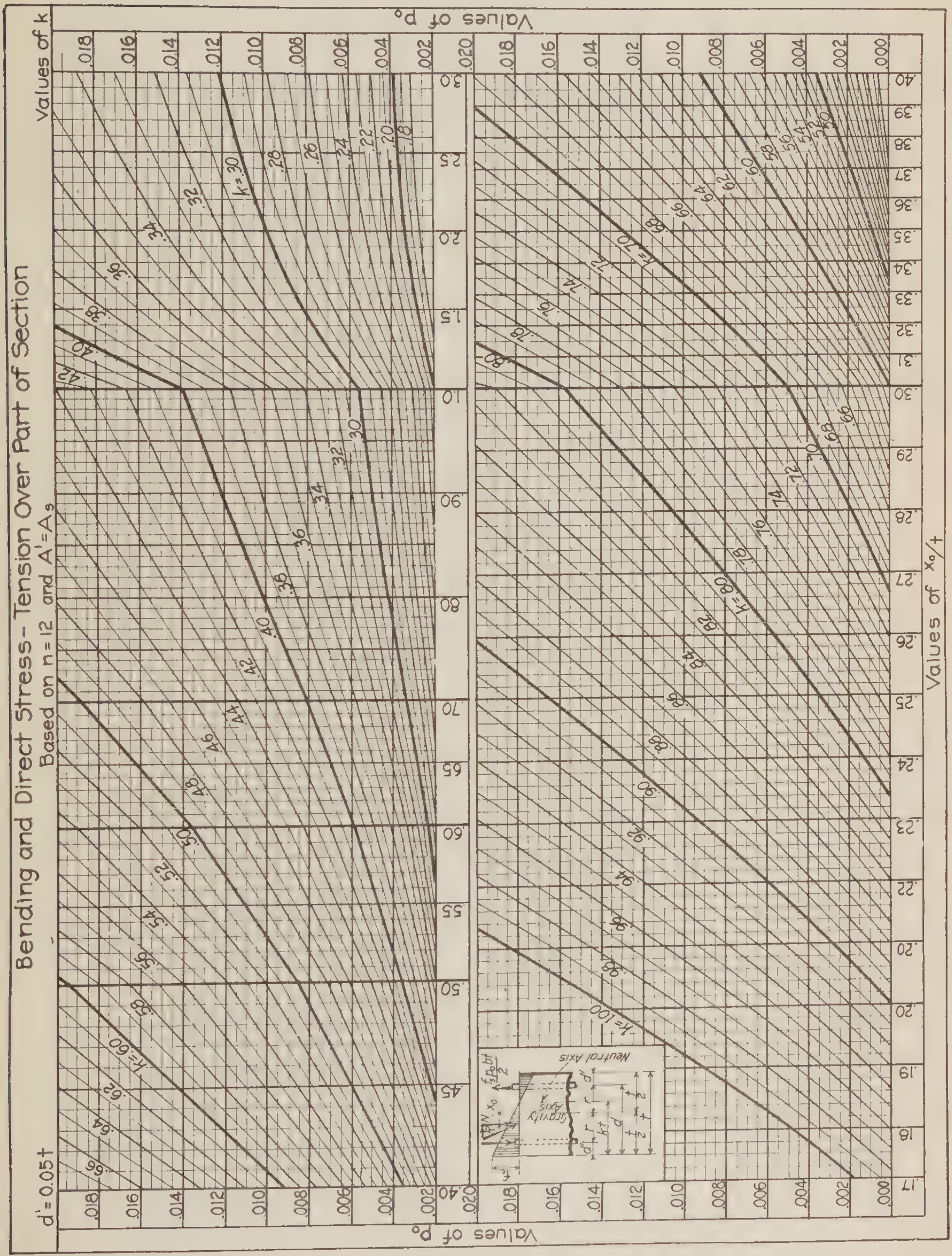
DIAGRAM 50

**BENDING
AND
DIRECT STRESS**

# RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION

$d' = 0.05t$
$n = 12$
$A' = A_s$

## *VALUES OF k*

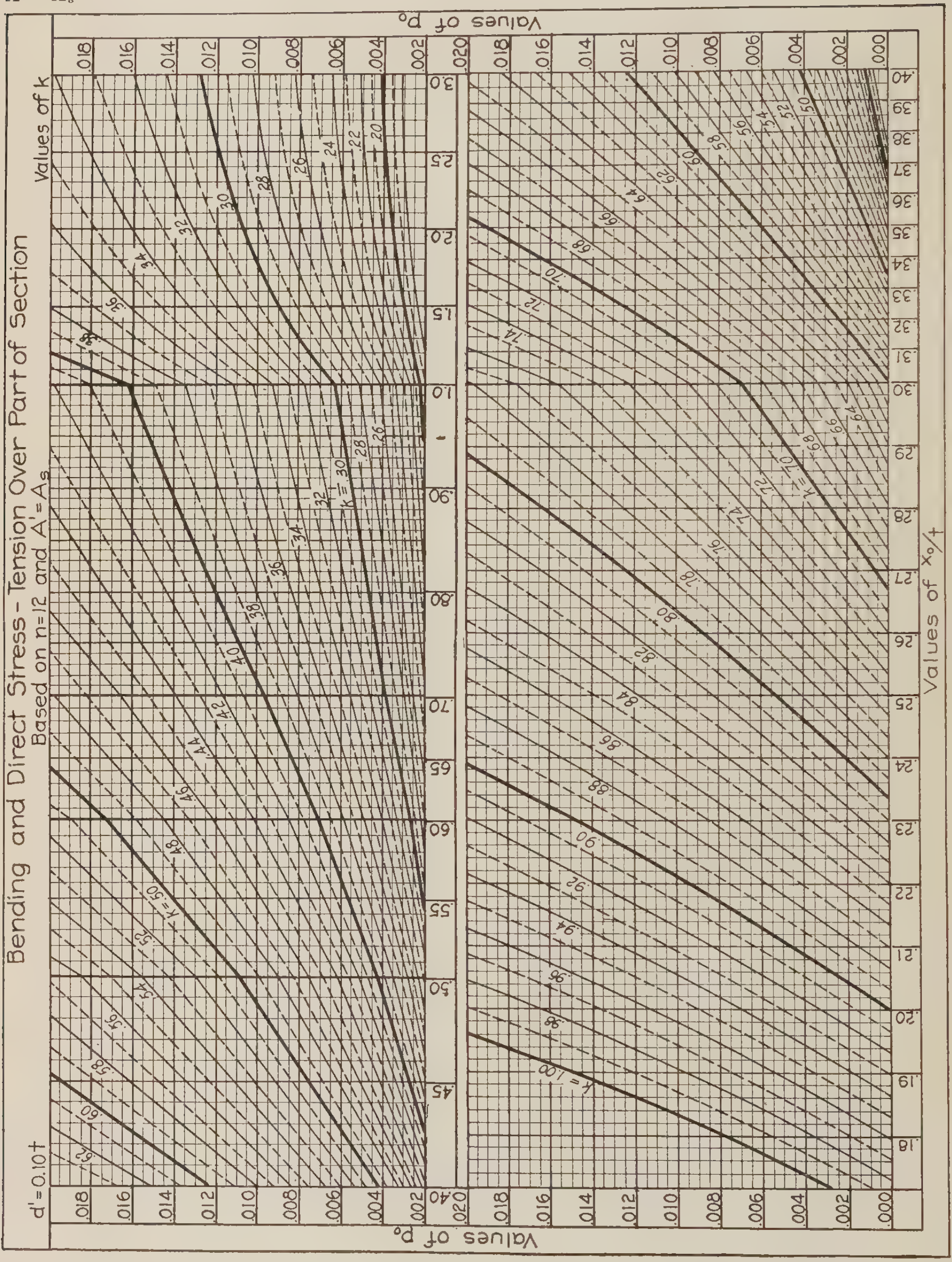


**BENDING
AND
DIRECT STRESS**

## RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION

$d' = 0.10t$
$n = 12$
$A' = A_s$

### VALUES OF $k$

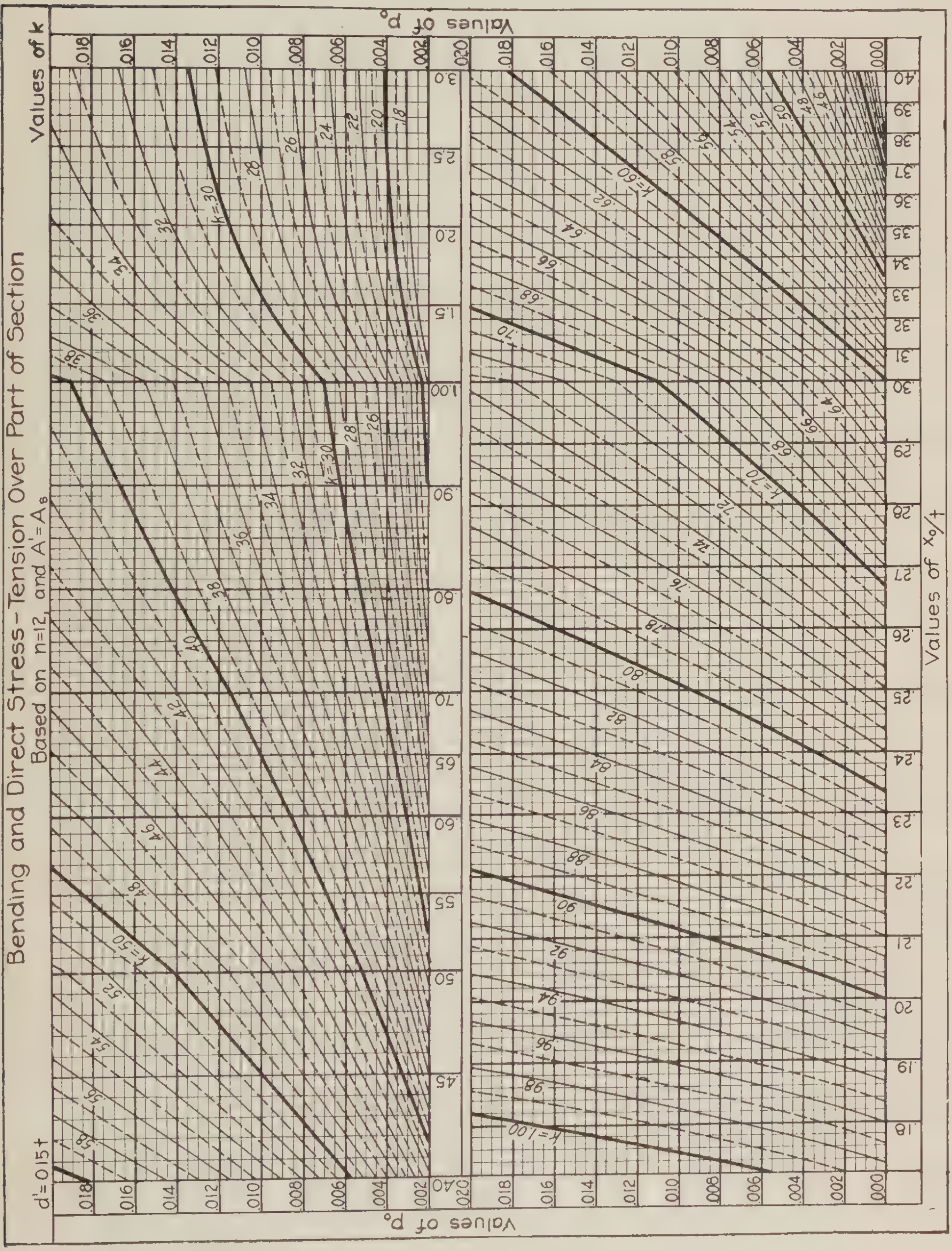


**BENDING AND DIRECT STRESS**

## RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION

### *VALUES OF k*

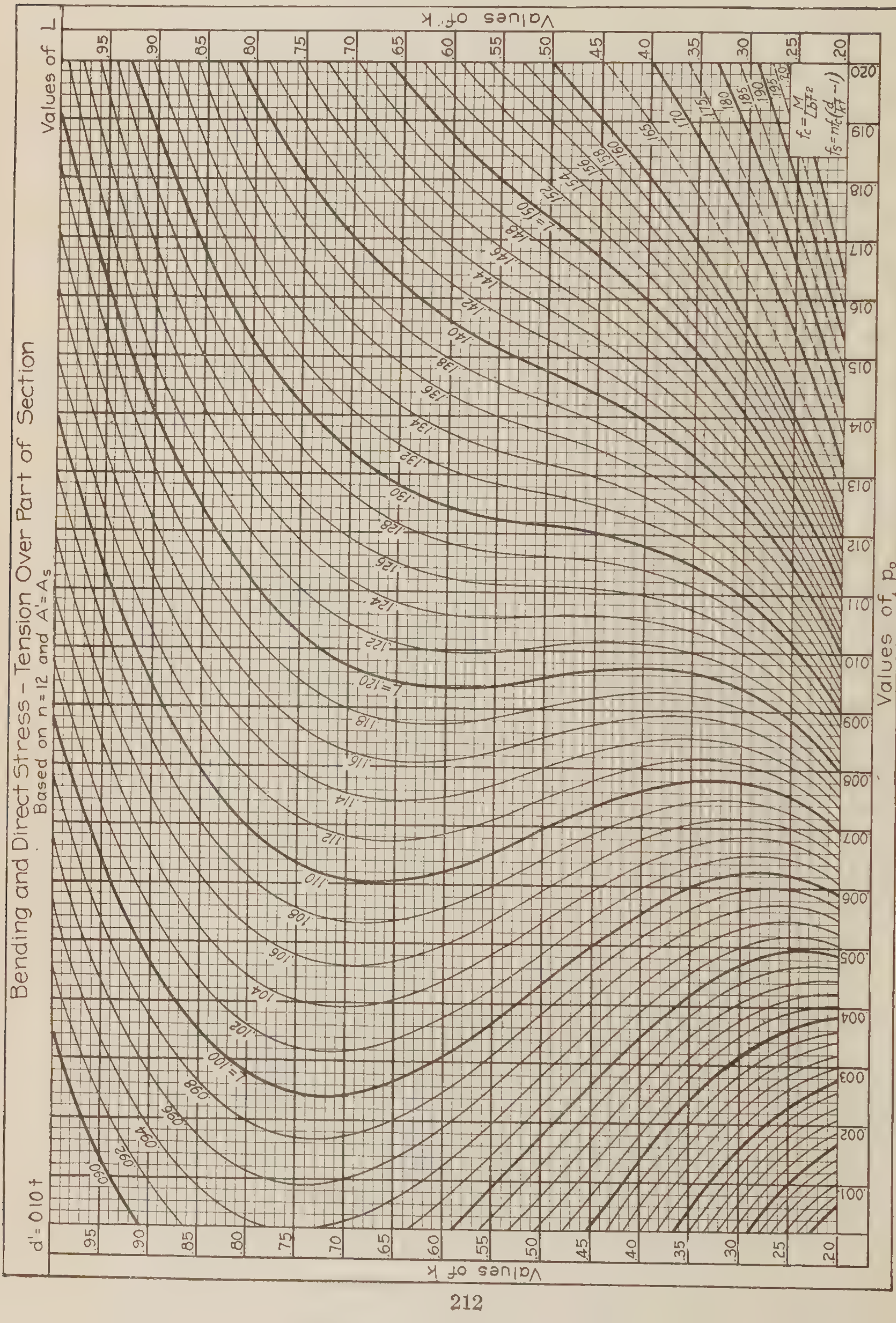
*d′* = 0.15*t*
*n* = 12
*A′* = $A_s$



## RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION

$d' = 0.10t$
$n = 12$
$A' = A_s$

### VALUES OF $\frac{M}{bt^2 f_c}$



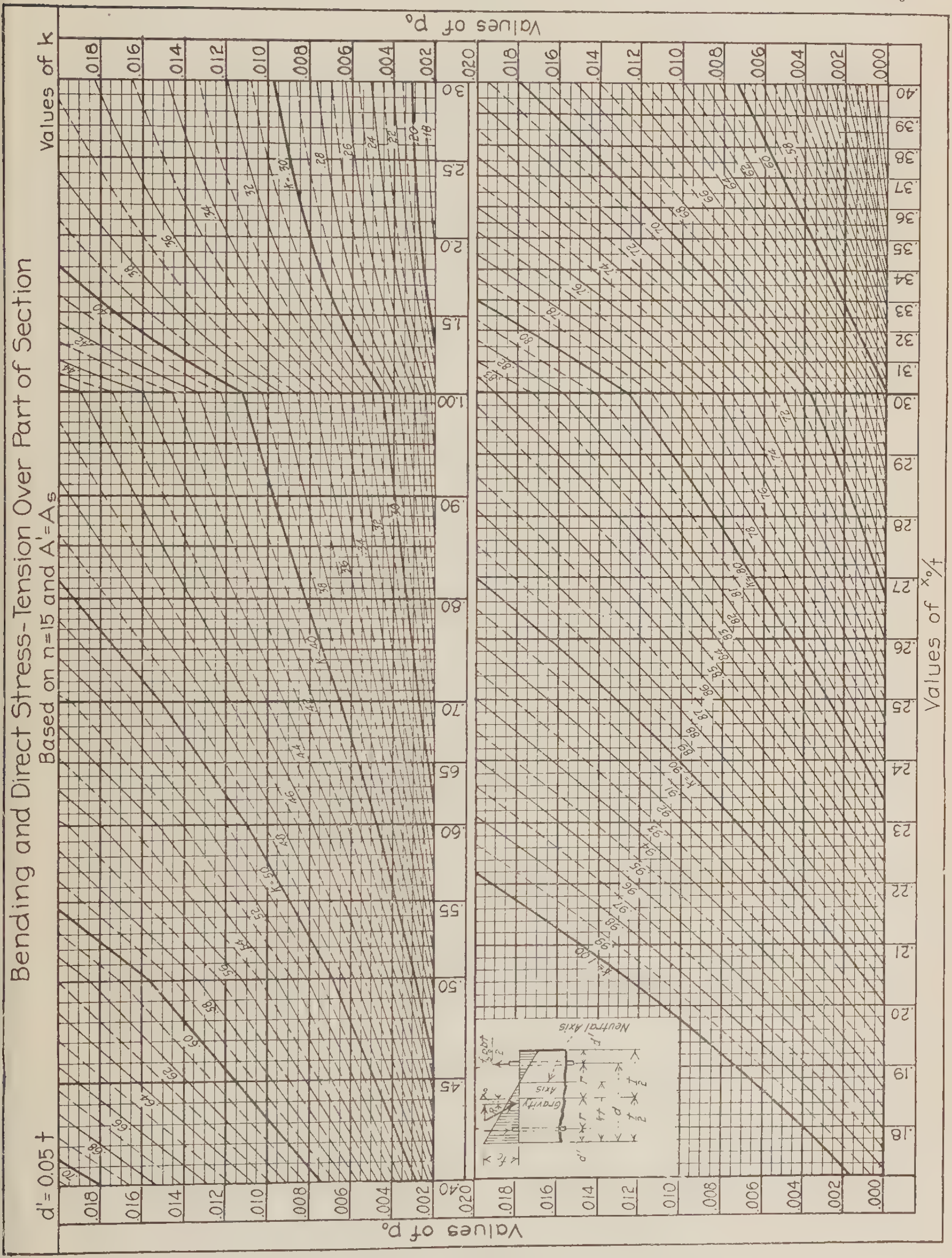
For $d' = 0.05t$, divide $p_0$ by 0.790 and find value of $L$ from above diagram.
For $d' = 0.15t$, divide $p_0$ by 1.306 and find value of $L$ from above diagram.

BENDING
AND
DIRECT STRESS

## RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION

### *VALUES OF k*

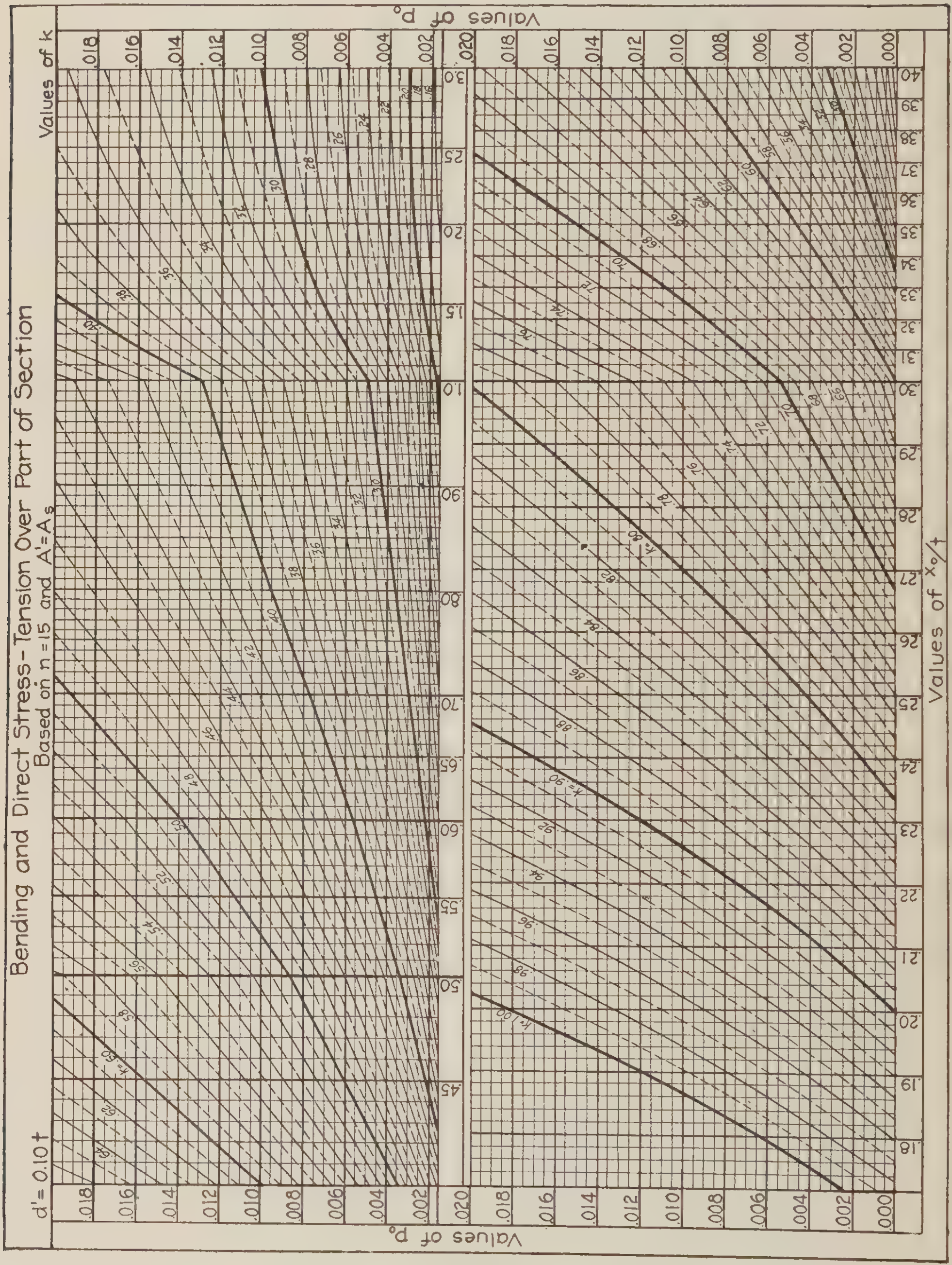
$d' = 0.05t$
$n = 15$
$A' = A_s$



## RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION

$d' = 0.10t$
$n = 15$
$A' = A_s$

### VALUES OF *k*

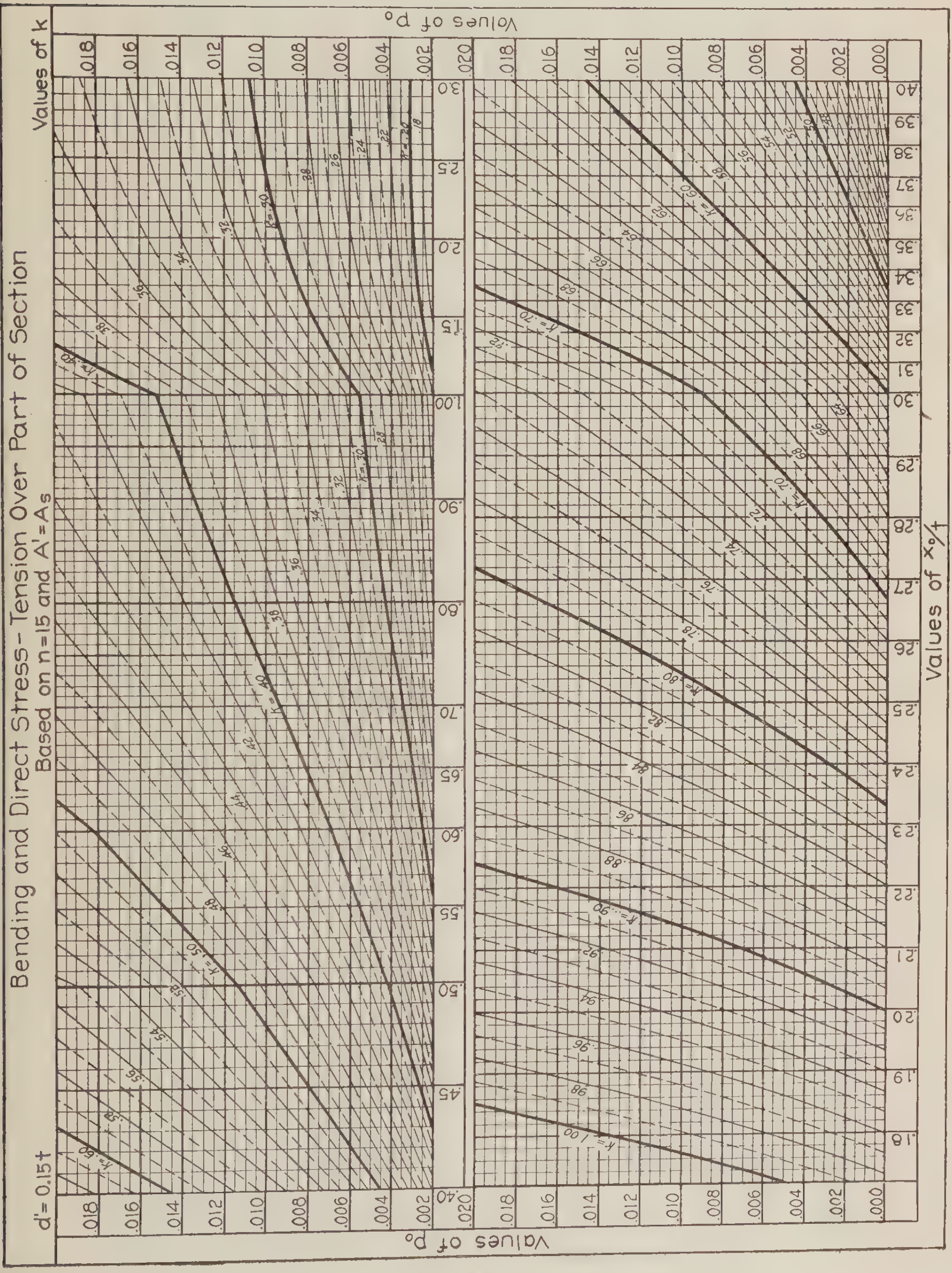


**BENDING**
**AND**
**DIRECT STRESS**

# RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION

## *VALUES OF k*

$d' = 0.15t$
$n = 15$
$A' = A_s$

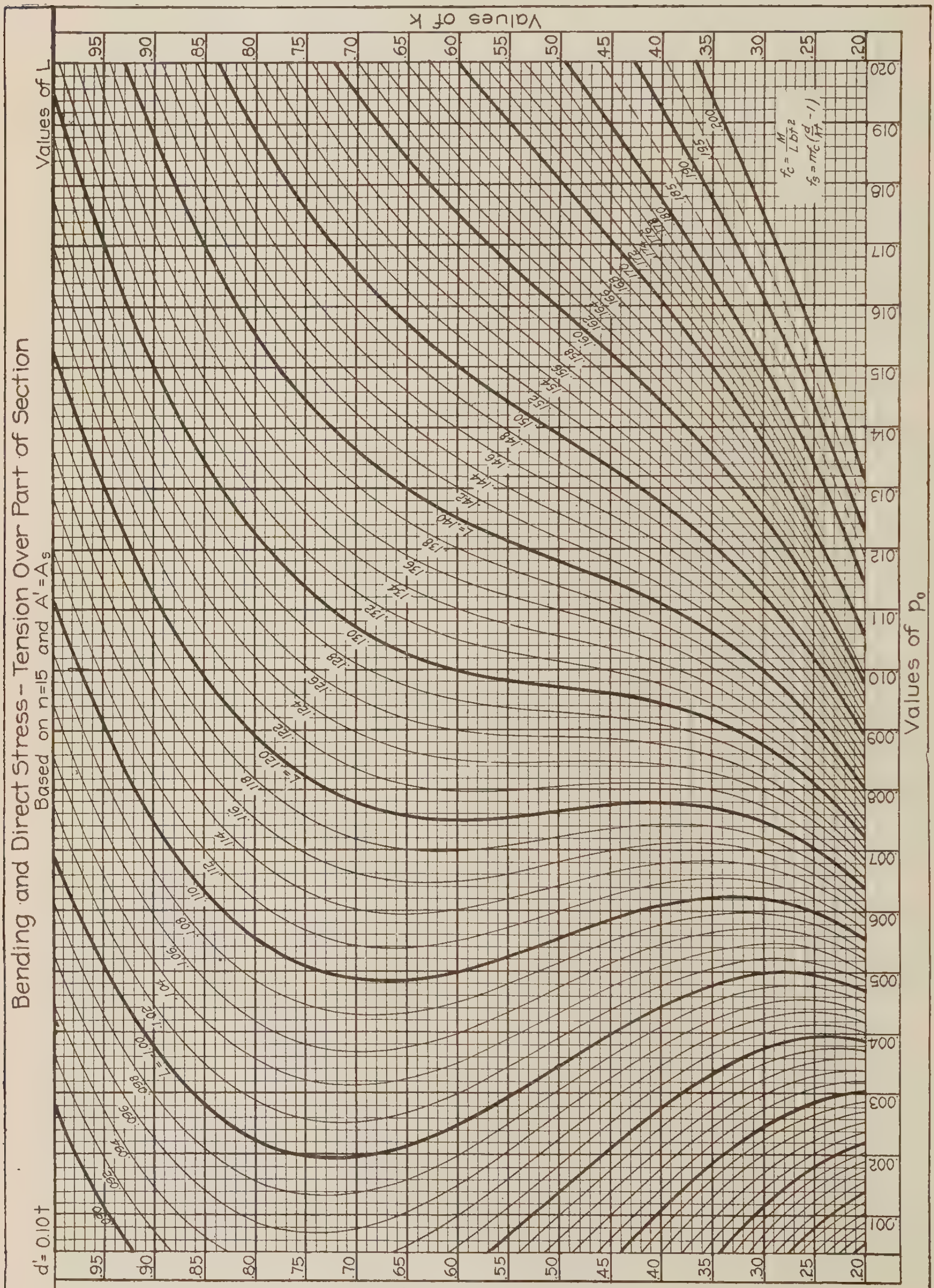


**BENDING AND DIRECT STRESS**

## RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION

$d' = 0.10t$
$n = 15$
$A' = A_s$

VALUES OF $\frac{M}{bt^2 f_c}$



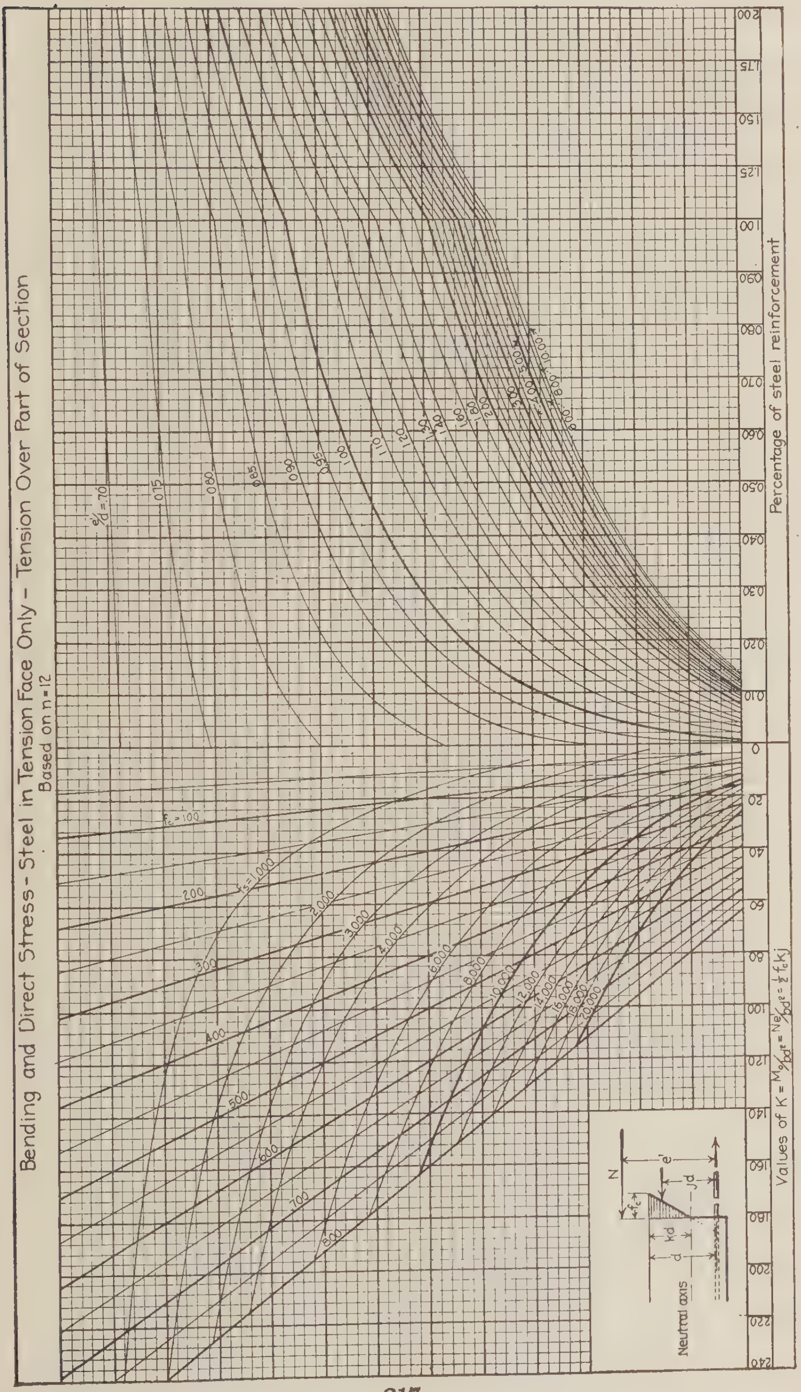
For $d' = 0.05t$, divide $p_o$ by 0.790 and find value of $L$ from above diagram.

**BENDING AND DIRECT STRESS**

## RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION STEEL IN TENSION FACE ONLY

### *VALUES OF $f_c$, $f_s$ AND $p$*

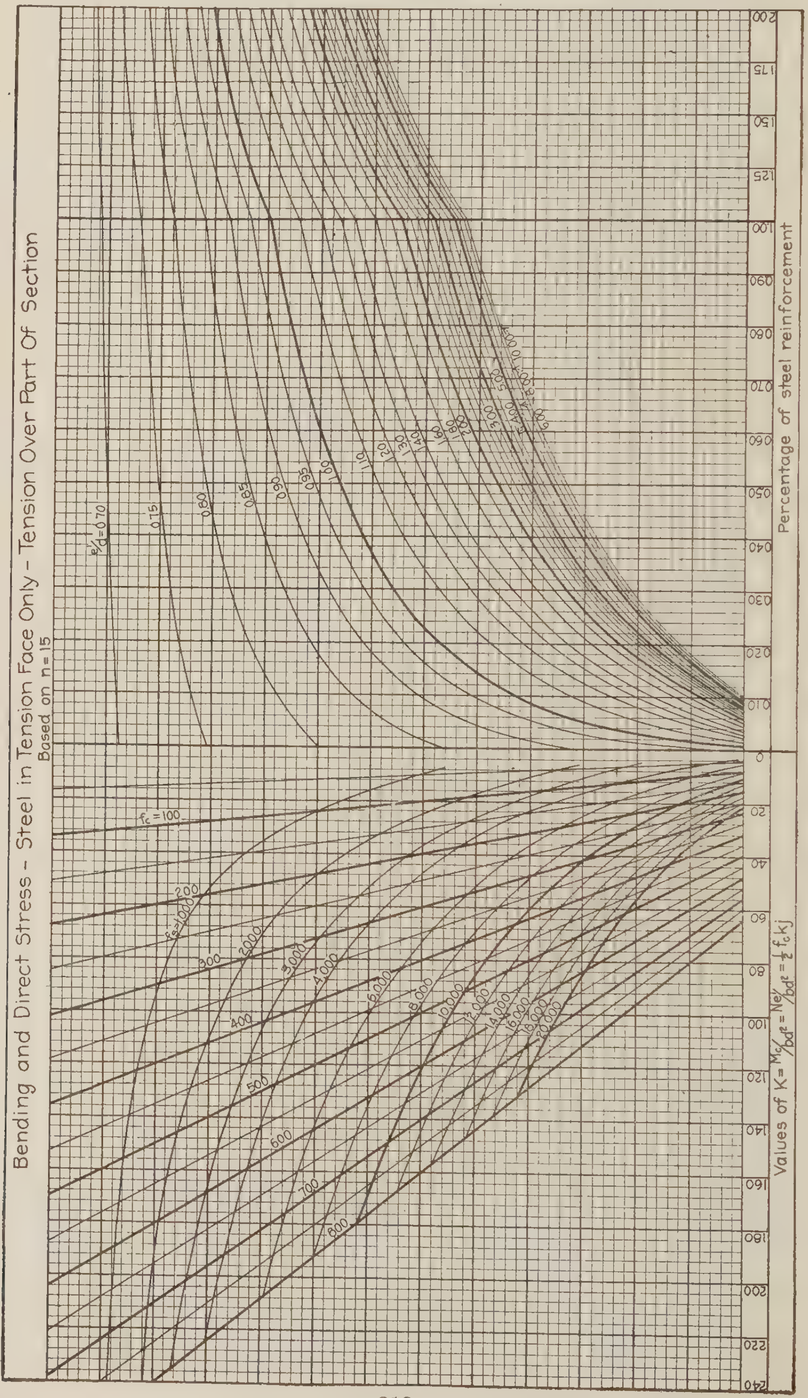
$n = 12$
$A' = 0$



## RECTANGULAR SECTIONS—TENSION OVER PART OF SECTION
## STEEL IN TENSION FACE ONLY

*$n = 15$*
*$A' = 0$*

### *VALUES OF $f_c$, $f_s$ AND $p$*

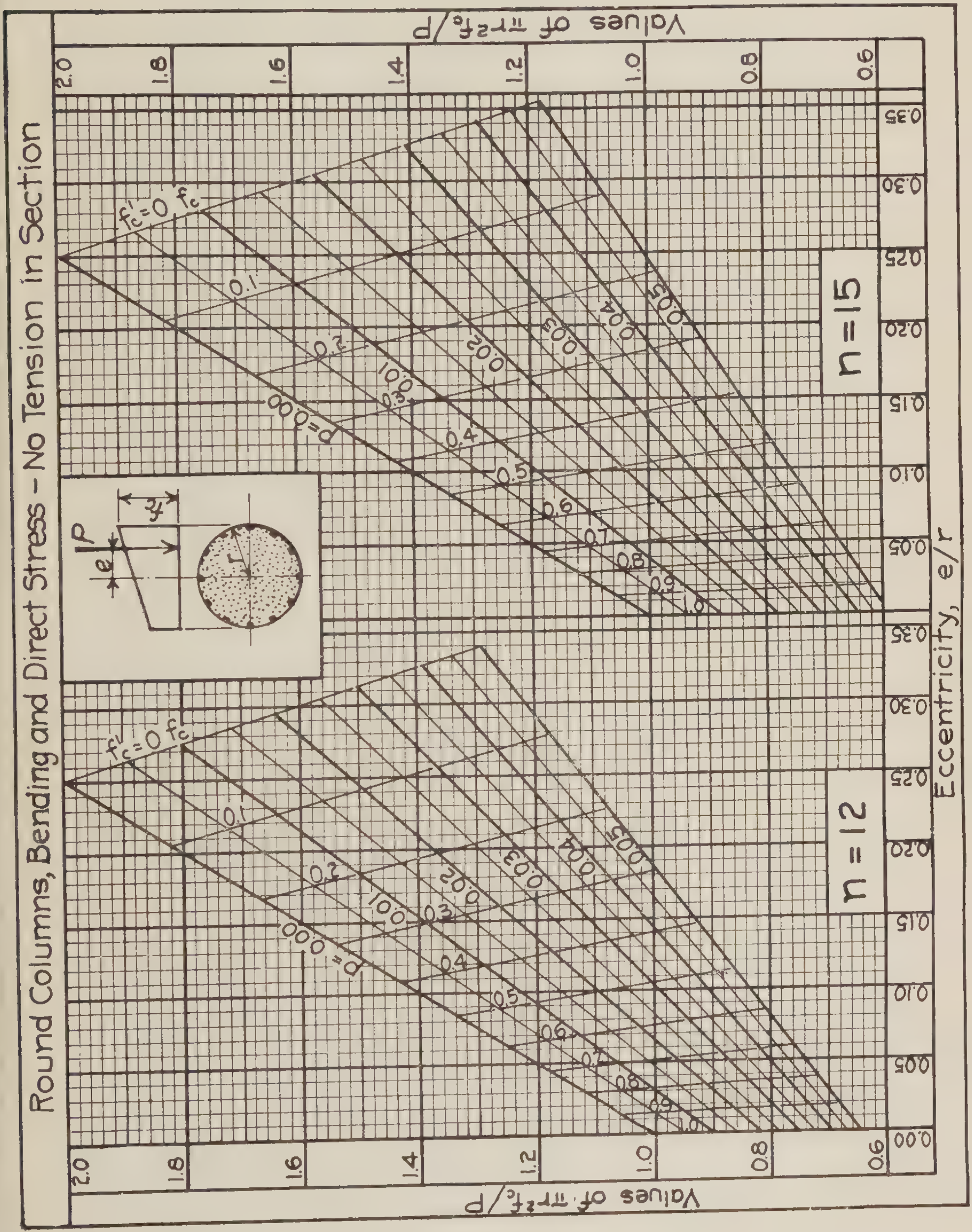


BENDING
AND
DIRECT STRESS

## ROUND COLUMNS—COMPRESSION OVER WHOLE SECTION

*VALUES OF* $\frac{\pi r^2 f_c}{P}$

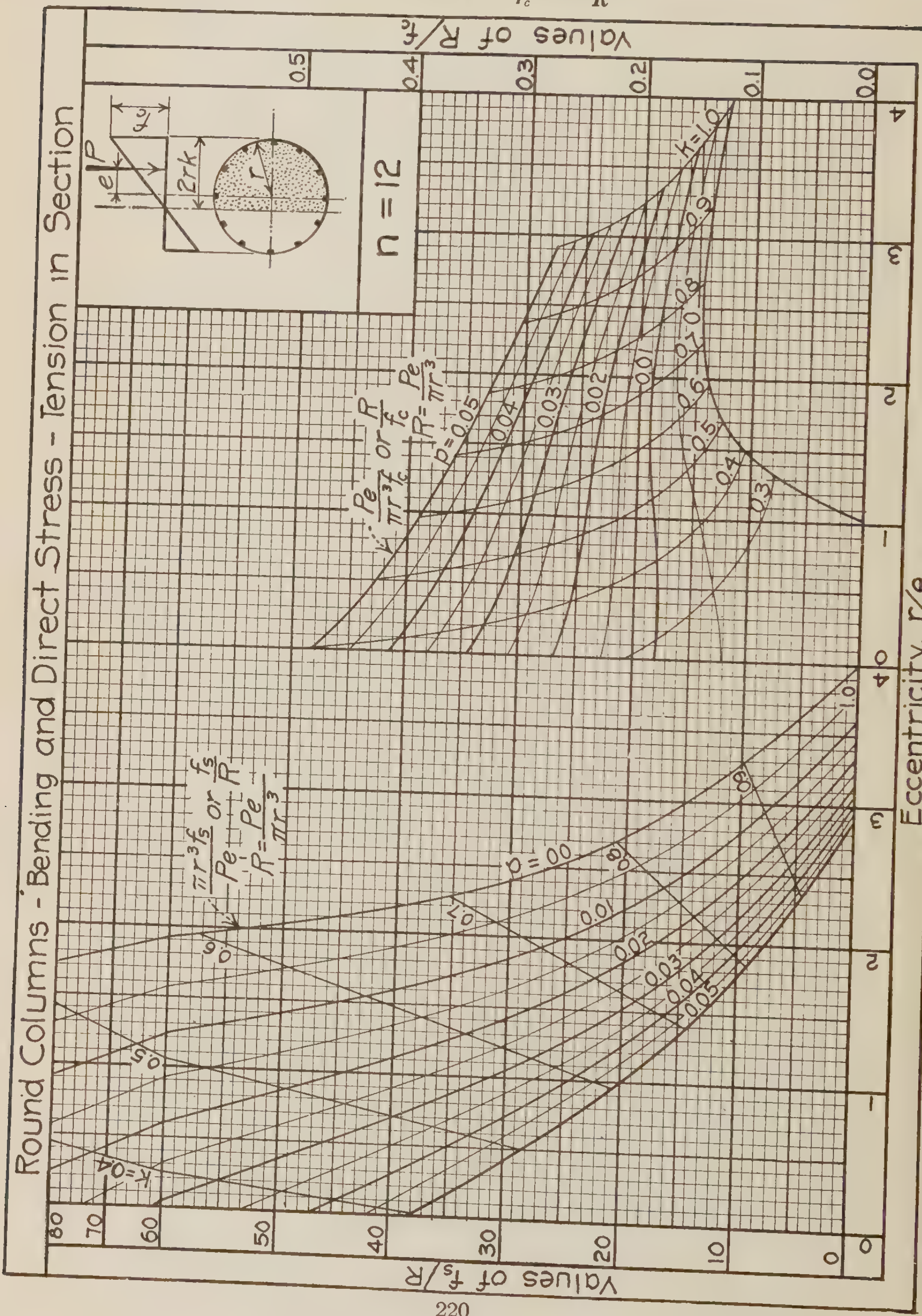
$n = 12$
$n = 15$



## ROUND COLUMNS—TENSION OVER PART OF SECTION

$n=12$

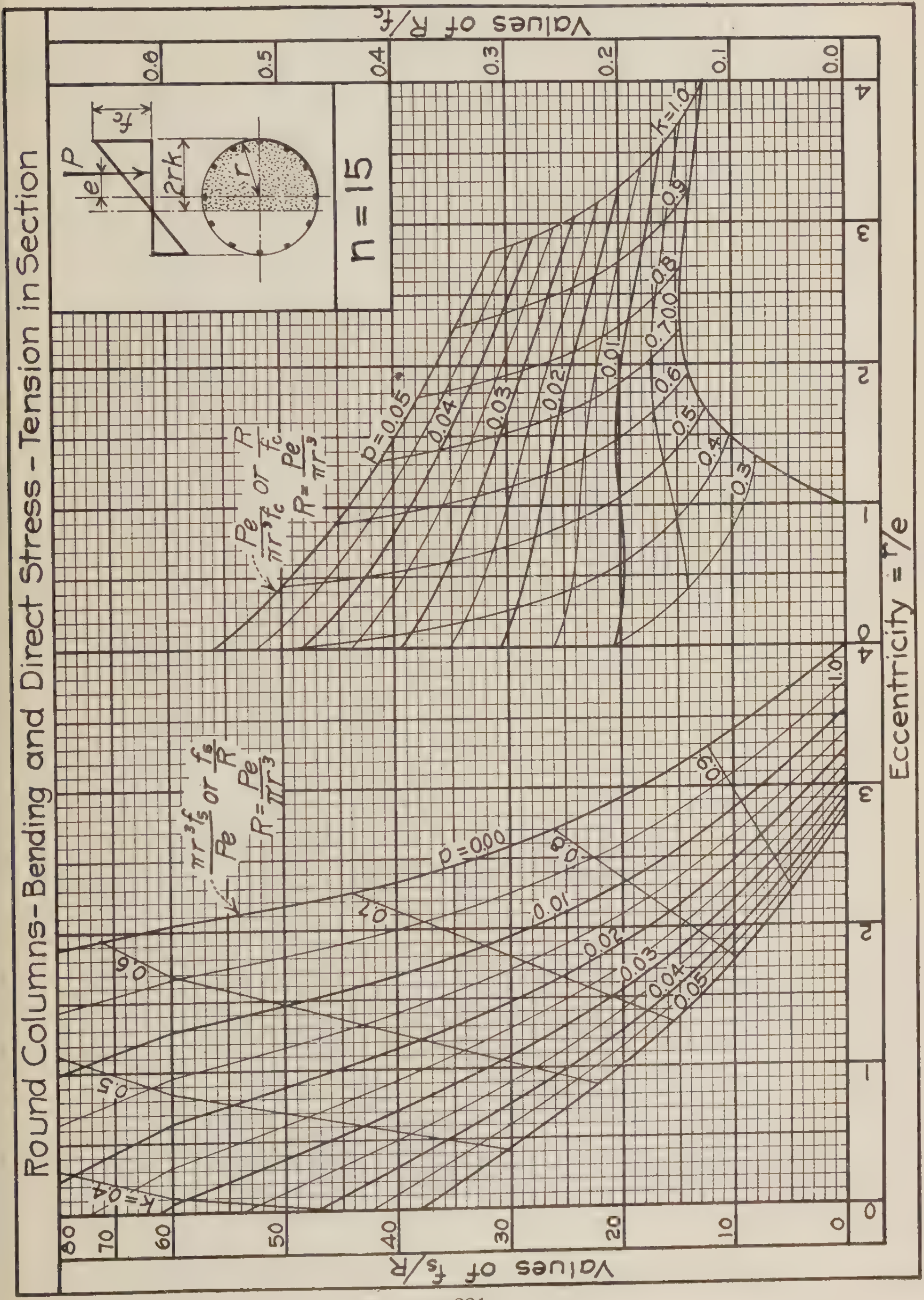
### VALUES OF $\frac{R}{f_c}$ AND $\frac{f_s}{R}$



## ROUND COLUMNS—TENSION OVER PART OF SECTION

*VALUES OF* $\frac{R}{f_c}$ *AND* $\frac{f_s}{R}$

$n = 15$

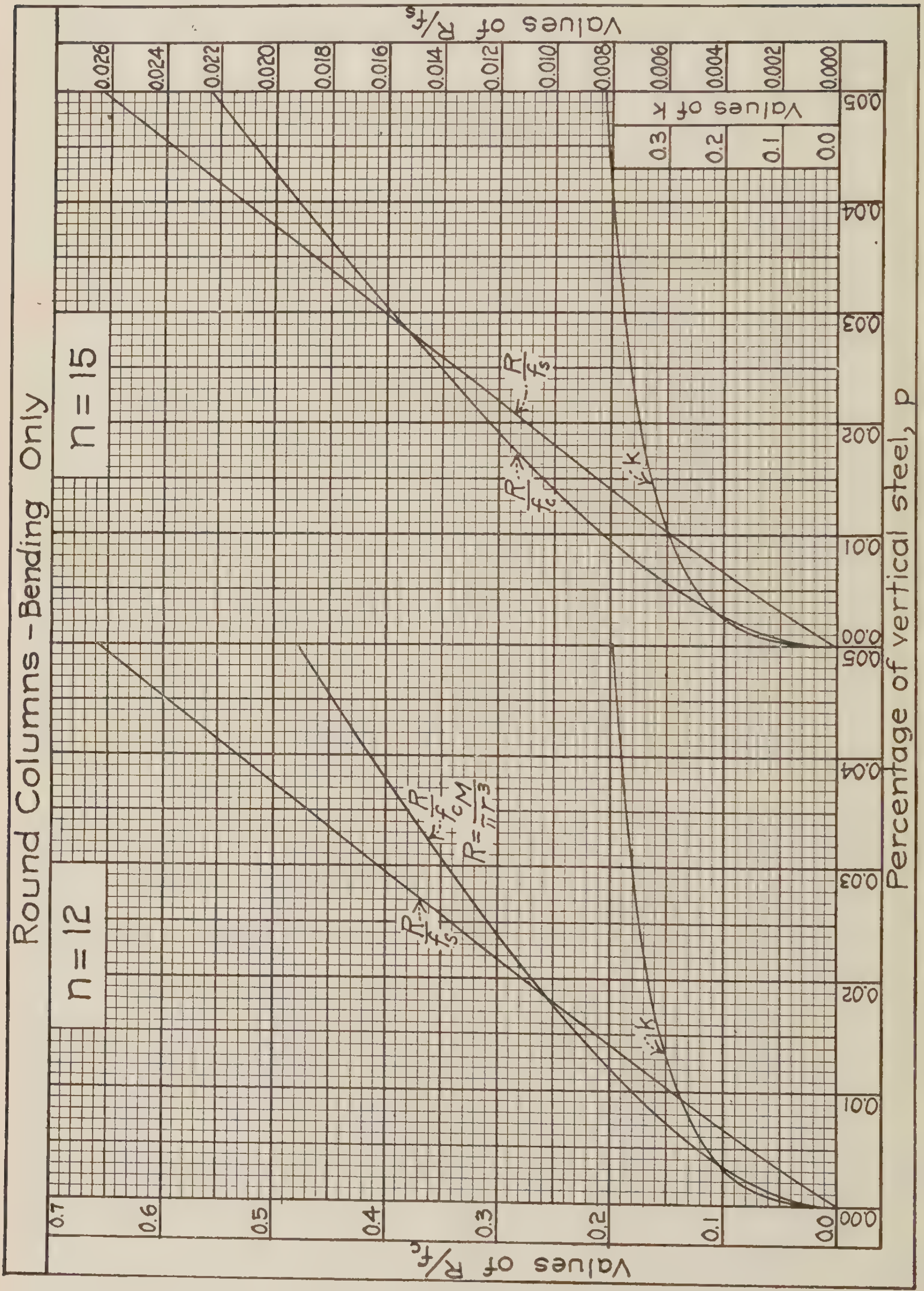


**BENDING
AND
DIRECT STRESS**

## ROUND COLUMNS—BENDING ONLY

$n = 12$
$n = 15$

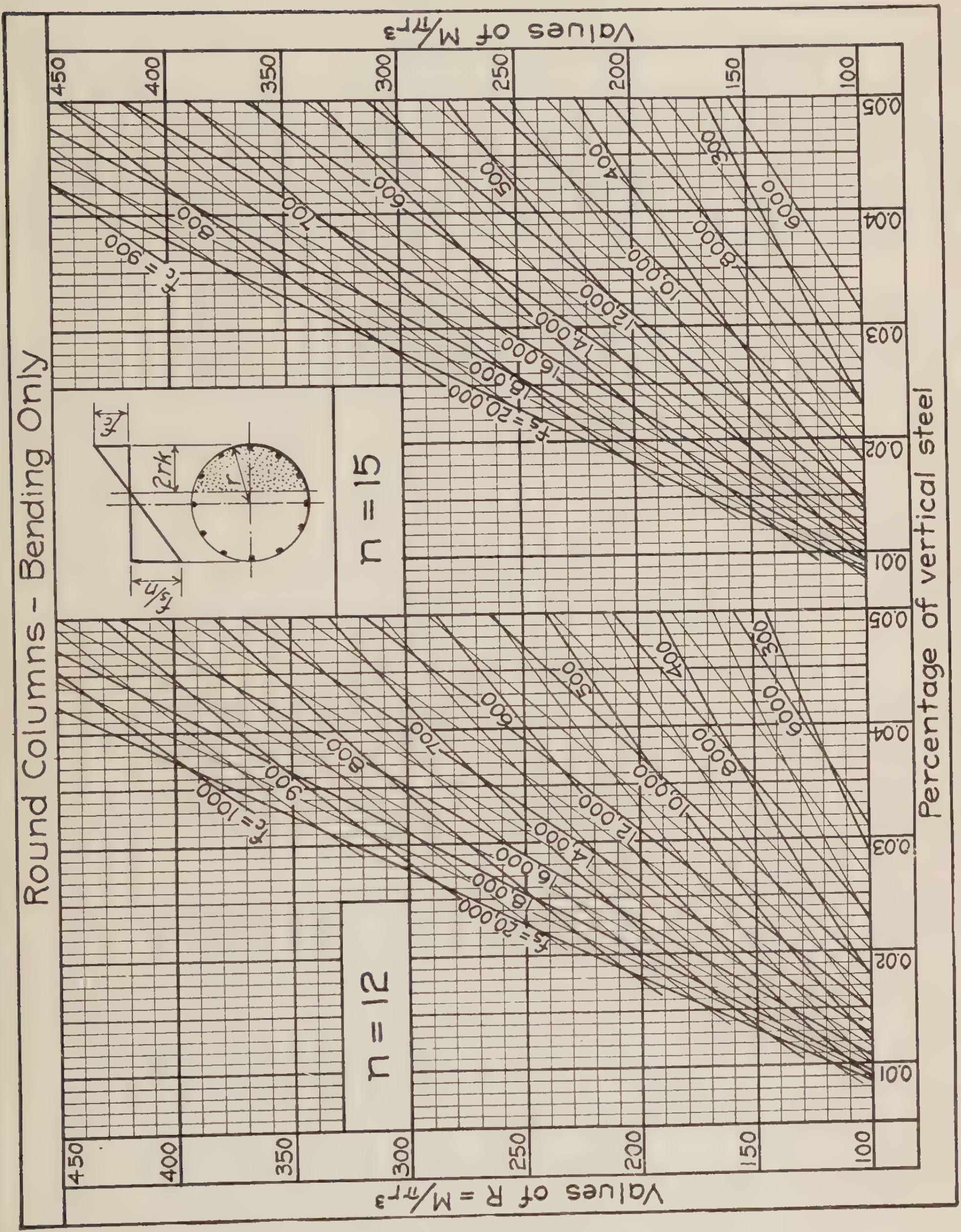
## VALUES OF $k$, $\frac{R}{f_s}$, $\frac{R}{f_c}$, AND $p$



## ROUND COLUMNS—BENDING ONLY

### *VALUES OF R, $f_s$, $f_c$ AND p*

$n = 12$
$n = 15$



## SECTION 9

## FOOTINGS

Diagram 65 makes it possible to find readily the bending moments which occur at each face of column for both square and rectangular footings. The illustrations above this diagram show how the diagram is used. For example, suppose the bending moment is required at the face of a 24-in. column supporting a load of 300,000 lb. and resting on a footing 9 ft. 2 in. square. From the upper part of Diagram 65, $C_1 = 6.2$ and

$$M = (6.2)(300{,}000) = 1{,}860{,}000 \text{ in.-lb.}$$

Tables 49, 50 and 51, based on the recommendations contained in Bulletin 67 of the University of Illinois Engineering Experiment Station, give the design of square reinforced footings for different loads, column sizes and soil pressure. These footings are without offsets and for large footings it will usually be found more economical to use one or two offsets.

These tables are computed for square columns. If round columns are used, multiply the diameter by 0.7854 to get the size of square columns of equivalent perimeter and enter the table with that size.

The recommendations in the bulletin mentioned above are as follows:

**Width of Footing to Use in Flexure Computations for Two-way Reinforcement.**—With two-way reinforcement evenly spaced over the footing, it seems that the tensile stress is approximately the same in bars lying within a space somewhat greater than the width of the pier and that there is also considerable stress in the bars which lie near the edges of the footing. For intermediate bars stresses intermediate in amount will be developed. For footings having two-way reinforcement spaced uniformly over the footing, the method proposed for determining the maximum tensile stress in the reinforcing bars, is to use in the calculation of resisting moment at a section at the face of the pier the area of all the bars which lie within a width of footing equal to the width of pier plus twice the thickness of footing, plus half the remaining distance on each side to the edge of the footing. This method gives results in keeping with the results of tests. When the spacing through the middle of the width of the footing is closer, or even when the bars are concentrated in the middle portion, the same method may be applied without serious error. Enough reinforcement should be placed in the outer portion to prevent the concentration of tension cracks in the concrete and to provide for other distribution of stress.

No failures of concrete have been observed in tests and none would be expected with the low percentages of reinforcement used.

**Bond Stresses.**—The method proposed for calculating maximum bond stress in column footings having two-way reinforcement evenly spaced, or spaced as noted in the preceding paragraph, is to use the ordinary bond stress formula, and to consider the circumference of all the bars which were used in the calculation of tensile stress, and to take for the external shear that amount of upward pressure or load which was used in the calculation of the bending moment at the given section.

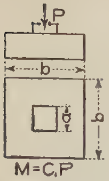
Bond resistance is one of the most important features of strength of column footings, and probably much more important than is appreciated by the average designer. The calculations of bond stress in footings of ordinary dimensions where large reinforcing bars are used show that the bond stress may be the governing element of strength. Tests show that in multiple-way reinforcement a special phenomenon affects the problem and that lower bond resistance may be found in footings than in beams. Longitudinal cracks form under and along the reinforcing bar due to the stretch in the reinforcing bars which extend in another direction, and these cracks act to reduce the bond resistance. The development of these cracks along the reinforcing bars must be expected in service under high tensile stresses, and low working bond stresses should be selected. An advantage will be found in placing under the bars a thickness of concrete of 2 in., or better 3 in., for footings of the size ordinarily used in buildings.

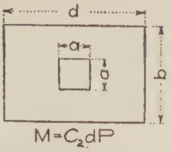
Difficulty may be found in providing the necessary bond resistance, and this points to an advantage in the use of bars of small size, even if they must be closely spaced. Generally speaking, bars of ¾-in. size or smaller will be found to serve the purpose of footings of usual dimensions. The use of large bars, because of ease in placing, leads to the construction of footings which are insecure in bond resistance. Column footings reinforced with deformed bars develop high bond resistance. Curving the bar upward and backward at the end increases the bond resistance, but this form is awkward in construction. Reinforcement formed by bending long bars in a series of horizontal loops covering the whole footing gives a footing with high bond resistance.

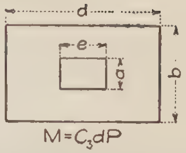
The use of short bars placed with their ends staggered increases the tendency to fail by bond and cannot be considered as acceptable practice in footings of ordinary proportions. In footings in which the projection is short in comparison with the depth, the objection is very great.

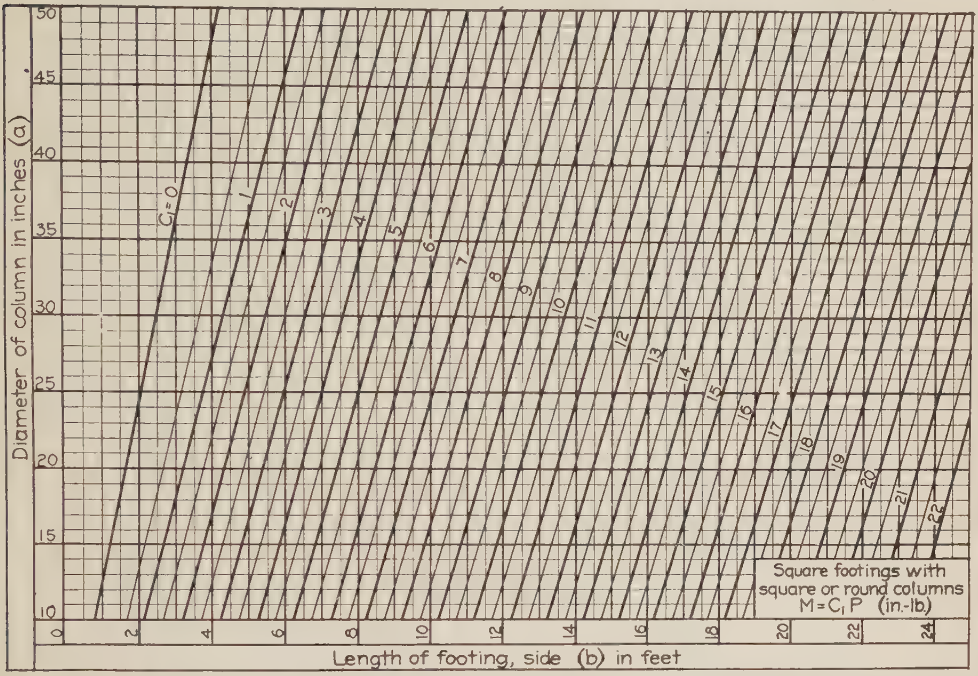
**Diagonal Tension.**—As a means of measuring resistance to diagonal tension failure, the vertical shearing stress should be calculated by using the vertical sections formed upon the square (assuming square column) which lies at a distance from the face of the pier equal to the depth of the footing. This calculation gives values of the shearing stress, for footings which failed by diagonal tension, which agree fairly closely with the values which have been obtained in tests of simple beams. The formula used in this calculation is $v = \frac{V}{bjd}$, where $V$ is the total vertical shear at this section taken to be equal to the upward pressure on the area of the footing outside of the section considered, $b$ is the total distance around the four sides of the section, and $jd$ is the distance from the center of reinforcing bars to the center of the compressive stresses. The working stress now frequently specified for this purpose in the design of beams, 40 lb. per sq. in., for 1 : 2 : 4 concrete, may be applied to the design of footings.

# BENDING MOMENTS FOR SINGLE COLUMN FOOTINGS

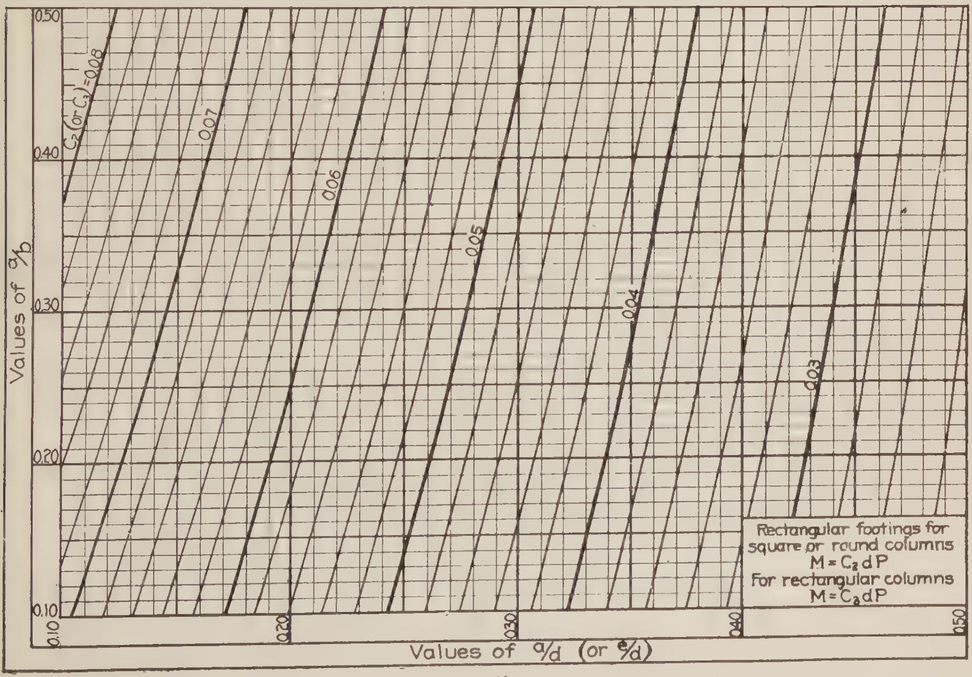








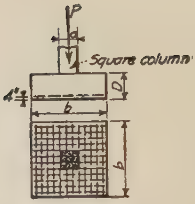
Square footings with square or round columns $M=C_1P$ (in.-lb.)



Rectangular footings for square or round columns $M=C_2dP$
For rectangular columns $M=C_3dP$

**FOOTINGS**

## DESIGN OF SINGLE SQUARE FOOTINGS
## 2 TONS ON SOIL

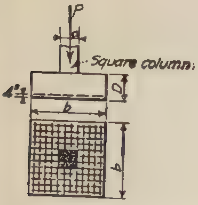


*Punching shear = 120*
*Bond stress = 100*
*Tension in steel = 16,000*

| Footing size *b* | | Column size *a* (in.) | Allowable load *P* (thousands of pounds) | Total depth *D* (in.) | Steel | | | | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| (ft.) | (in.) | | | | Size (in.) | No. rods each way | | Weight of sq. rods (lb.) | |
| | | | | | | Square | Round | | |
| 3 | 0 | 10 | 34.8 | 11 | ½ | 8 | 10 | 37.4 | 8.3 |
| | | 12 | 34.9 | 10 | | 9 | 12 | 42.0 | 7.5 |
| | | 14 | 35.0 | 9 | | 10 | 13 | 46.7 | 6.8 |
| 3 | 6 | 10 | 46.9 | 14 | ½ | 8 | 10 | 44.2 | 14.3 |
| | | 12 | 47.2 | 12 | | 10 | 12 | 55.2 | 12.3 |
| | | 14 | 47.3 | 11 | | 11 | 13 | 60.7 | 11.3 |
| 4 | 0 | 10 | 60.6 | 17 | ½ | 8 | 10 | 51.0 | 22.7 |
| | | 12 | 61.2 | 14 | | 10 | 13 | 63.7 | 18.7 |
| | | 14 | 61.4 | 13 | | 11 | 14 | 70.1 | 17.3 |
| | | 16 | 61.6 | 12 | | 12 | 15 | 76.5 | 16.0 |
| 4 | 6 | 10 | 75.9 | 20 | ½ | 8 | 10 | 57.7 | 33.8 |
| | | 12 | 76.7 | 17 | | 10 | 12 | 72.2 | 28.7 |
| | | 14 | 77.2 | 15 | | 12 | 15 | 86.6 | 25.3 |
| | | 16 | 77.7 | 13 | | 14 | 18 | 101.0 | 22.0 |
| 5 | 0 | 10 | 92.7 | 23 | ½ | 8 | 10 | 64.6 | 47.9 |
| | | 12 | 93.7 | 20 | | 10 | 12 | 80.7 | 41.7 |
| | | 14 | 94.4 | 18 | | 11 | 14 | 88.8 | 37.5 |
| | | 16 | 95.0 | 16 | | 13 | 16 | 105 | 33.4 |
| | | 18 | 95.6 | 14 | | 16 | 20 | 129 | 29.2 |
| 5 | 6 | 10 | 110.8 | 27 | ½ | 8 | 10 | 71.4 | 68.0 |
| | | 12 | 112.8 | 23 | | 10 | 12 | 89.2 | 58.0 |
| | | 14 | 113.4 | 20 | | 12 | 15 | 107 | 50.4 |
| | | 16 | 114.2 | 18 | | 13 | 17 | 116 | 45.4 |
| | | 18 | 114.6 | 17 | | 14 | 18 | 125 | 42.8 |
| 6 | 0 | 10 | 130.1 | 31 | ½ | 7 | 9 | 68.4 | 93.0 |
| | | 12 | 131.8 | 27 | | 9 | 11 | 88.0 | 81.0 |
| | | 14 | 133.2 | 24 | | 11 | 14 | 108 | 72.0 |
| | | 16 | 134.5 | 21 | | 13 | 16 | 127 | 63.0 |
| | | 18 | 135.4 | 19 | | 15 | 19 | 147 | 57.0 |
| | | 20 | 136.3 | 17 | | 17 | 22 | 166 | 51.0 |
| | | 22 | 136.8 | 16 | | 18 | 23 | 176 | 48.0 |
| 6 | 6 | 10 | 150.5 | 35 | ½ | 8 | 10 | 85 | 123.0 |
| | | 12 | 153.1 | 30 | | 10 | 12 | 106 | 106.0 |
| | | 14 | 154.7 | 27 | | 11 | 14 | 117 | 95.0 |
| | | 16 | 156.3 | 24 | | 13 | 16 | 138 | 84.5 |
| | | 18 | 157.3 | 22 | | 14 | 18 | 149 | 77.5 |
| | | 20 | 158.4 | 20 | | 16 | 20 | 170 | 70.4 |
| | | 22 | 158.9 | 19 | | 17 | 21 | 181 | 67.2 |

TABLE 49

**FOOTINGS**



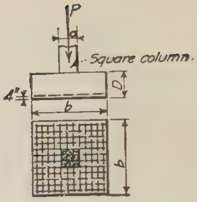
# DESIGN OF SINGLE SQUARE FOOTINGS

## 2 TONS ON SOIL.

*Punching shear = 120*
*Bond stress = 100*
*Tension in steel = 16,000*

| Footing size *b* | | Column size *a* (in.) | Allowable load *P* (thousands of pounds) | Total depth *D* (in.) | Steel | | | | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Size (in.) | No. rods each way | | Weight of sq. rods (lb.) | |
| (ft.) | (in.) | | | | | Square | Round | | |
| 7 | 0 | 12 | 175.1 | 34 | ½ | 10 | 12 | 115 | 139 |
| | | 14 | 177.6 | 30 | | 12 | 15 | 138 | 123 |
| | | 16 | 179.5 | 27 | | 13 | 17 | 149 | 110 |
| | | 18 | 181.3 | 24 | | 14 | 18 | 161 | 98 |
| | | 20 | 182.5 | 22 | | 17 | 21 | 195 | 90 |
| | | 22 | 183.1 | 21 | | 17 | 22 | 195 | 86 |
| | | 24 | 184.4 | 19 | | 20 | 25 | 230 | 78 |
| 7 | 6 | 12 | 198.3 | 38 | ½ | 11 | 14 | 136 | 178 |
| | | 14 | 201.1 | 34 | | 13 | 16 | 160 | 160 |
| | | 16 | 203.9 | 30 | | 15 | 18 | 185 | 141 |
| | | 18 | 206.0 | 27 | | 16 | 21 | 197 | 127 |
| | | 20 | 207.4 | 25 | | 17 | 22 | 210 | 117 |
| | | 22 | 208.8 | 23 | | 19 | 24 | 234 | 108 |
| | | 24 | 210.2 | 21 | | 20 | 26 | 246 | 99 |
| 8 | 0 | 14 | 226.4 | 37 | ½ | 14 | 17 | 185 | 198 |
| | | 16 | 229.6 | 33 | | 16 | 20 | 211 | 176 |
| | | 18 | 232.0 | 30 | | 17 | 22 | 224 | 160 |
| | | 20 | 233.6 | 28 | | 18 | 23 | 237 | 149 |
| | | 22 | 235.2 | 26 | | 20 | 25 | 264 | 139 |
| | | 24 | 236.8 | 24 | | 21 | 27 | 277 | 128 |
| | | 26 | 238.4 | 22 | | 23 | 29 | 303 | 117 |
| 8 | 6 | 14 | 252.0 | 41 | ½ | 14 | 18 | 196 | 247 |
| | | 16 | 255.6 | 37 | | 16 | 21 | 224 | 223 |
| | | 18 | 259.2 | 33 | | 19 | 24 | 267 | 199 |
| | | 20 | 261.9 | 30 | | 21 | 26 | 294 | 181 |
| | | 22 | 263.7 | 28 | | 22 | 28 | 309 | 169 |
| | | 24 | 265.5 | 26 | | 24 | 30 | 337 | 156 |
| | | 26 | 267.3 | 24 | | 25 | 32 | 351 | 145 |
| 9 | 0 | 16 | 283.5 | 40 | ⅝ | 11 | 14 | 256 | 270 |
| | | 18 | 286.5 | 37 | | 12 | 16 | 279 | 250 |
| | | 20 | 289.5 | 34 | | 14 | 17 | 325 | 230 |
| | | 22 | 292.7 | 31 | | 15 | 19 | 349 | 209 |
| | | 24 | 294.4 | 29 | | 16 | 20 | 372 | 197 |
| | | 26 | 296.6 | 27 | | 17 | 22 | 395 | 182 |
| | | 28 | 298.7 | 25 | | 19 | 24 | 442 | 169 |
| 9 | 6 | 16 | 311.3 | 44 | ⅝ | 12 | 15 | 295 | 331 |
| | | 18 | 315.8 | 40 | | 13 | 17 | 319 | 301 |
| | | 20 | 319.3 | 37 | | 14 | 18 | 344 | 278 |
| | | 22 | 322.6 | 34 | | 16 | 20 | 393 | 256 |
| | | 24 | 326.0 | 31 | | 17 | 22 | 418 | 233 |
| | | 26 | 328.7 | 29 | | 18 | 23 | 442 | 218 |
| | | 28 | 330.6 | 27 | | 20 | 25 | 491 | 203 |

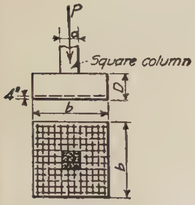
## DESIGN OF SINGLE SQUARE FOOTINGS
## 2 TONS ON SOIL



*Punching shear = 120*
*Bond stress = 100*
*Tension in steel = 16,000*

| Footing size b (ft.) | Footing size b (in.) | Column size a (in.) | Allowable load P (thousands of pounds) | Total depth D (in.) | Steel: Size (in.) | Steel: No. rods each way: Square | Steel: No. rods each way: Round | Steel: Weight of sq. rods (lb.) | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 0 | 16 | 340.0 | 48 | ⅝ | 12 | 16 | 310 | 400 |
| | | 18 | 346.3 | 43 | | 14 | 18 | 362 | 358 |
| | | 20 | 349.9 | 40 | | 15 | 19 | 388 | 334 |
| | | 22 | 353.8 | 37 | | 17 | 21 | 440 | 308 |
| | | 24 | 357.4 | 34 | | 18 | 23 | 466 | 284 |
| | | 26 | 360.0 | 32 | | 19 | 25 | 492 | 267 |
| | | 28 | 362.5 | 30 | | 20 | 26 | 518 | 250 |
| | | 30 | 365.0 | 28 | | 22 | 28 | 565 | 233 |
| 10 | 6 | 16 | 369.3 | 52 | ⅝ | 14 | 17 | 381 | 478 |
| | | 18 | 376.1 | 47 | | 15 | 19 | 408 | 432 |
| | | 20 | 381.8 | 43 | | 16 | 21 | 435 | 395 |
| | | 22 | 386.0 | 40 | | 18 | 23 | 490 | 367 |
| | | 24 | 390.0 | 37 | | 19 | 25 | 517 | 340 |
| | | 26 | 392.9 | 35 | | 20 | 26 | 544 | 321 |
| | | 28 | 395.5 | 33 | | 21 | 27 | 571 | 303 |
| | | 30 | 398.2 | 31 | | 22 | 28 | 599 | 285 |
| 11 | 0 | 18 | 406.9 | 51 | ⅝ | 15 | 19 | 419 | 514 |
| | | 20 | 414.5 | 46 | | 17 | 22 | 486 | 463 |
| | | 22 | 419.0 | 43 | | 19 | 24 | 543 | 433 |
| | | 24 | 423.5 | 40 | | 20 | 26 | 572 | 403 |
| | | 26 | 428.0 | 37 | | 22 | 28 | 629 | 373 |
| | | 28 | 431.0 | 35 | | 23 | 29 | 658 | 353 |
| | | 30 | 434.0 | 33 | | 24 | 31 | 686 | 333 |
| | | 32 | 437.2 | 31 | | 26 | 33 | 743 | 312 |
| | | 34 | 438.7 | 30 | | 26 | 33 | 743 | 302 |
| 11 | 6 | 18 | 439.7 | 54 | ⅝ | 16 | 21 | 478 | 595 |
| | | 20 | 446.3 | 50 | | 18 | 23 | 538 | 551 |
| | | 22 | 452.8 | 46 | | 20 | 25 | 598 | 507 |
| | | 24 | 457.8 | 43 | | 21 | 27 | 628 | 474 |
| | | 26 | 462.9 | 40 | | 23 | 29 | 687 | 441 |
| | | 28 | 466.3 | 38 | | 24 | 31 | 717 | 418 |
| | | 30 | 469.4 | 36 | | 25 | 32 | 747 | 397 |
| | | 32 | 472.7 | 34 | | 26 | 34 | 777 | 375 |
| | | 34 | 476.0 | 32 | | 28 | 35 | 837 | 353 |
| 12 | 0 | 18 | 471.4 | 58 | ⅝ | 17 | 22 | 530 | 697 |
| | | 20 | 480.5 | 53 | | 19 | 24 | 593 | 636 |
| | | 22 | 486.0 | 50 | | 20 | 26 | 624 | 600 |
| | | 24 | 493.2 | 46 | | 22 | 28 | 686 | 552 |
| | | 26 | 498.6 | 43 | | 24 | 31 | 748 | 516 |
| | | 28 | 502.1 | 41 | | 25 | 32 | 780 | 492 |
| | | 30 | 507.6 | 38 | | 27 | 35 | 841 | 456 |
| | | 32 | 511.1 | 36 | | 28 | 36 | 873 | 432 |
| | | 34 | 514.8 | 34 | | 30 | 38 | 936 | 408 |
| | | 36 | 518.4 | 32 | | 31 | 40 | 967 | 384 |

**TABLE 50**

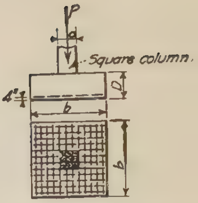


## DESIGN OF SINGLE SQUARE FOOTINGS

## 3 TONS ON SOIL

*Punching shear = 120*
*Bond stress = 100*
*Tension in steel = 16,000*

| Footing size $b$ | | Column size $a$ (in.) | Allowable load $P$ (thousands of pounds) | Total depth $D$ (in.) | Steel | | | | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| (ft.) | (in.) | | | | Size (in.) | No. rods each way | | Weight of sq. rods (lb.) | |
| | | | | | | Square | Round | | |
| 3 | 0 | 10 | 52.4 | 14 | ½ | 8 | 10 | 37.4 | 10.5 |
| | | 12 | 52.5 | 13 | | 8 | 11 | 37.4 | 9.8 |
| | | 14 | 52.8 | 11 | | 11 | 14 | 51.5 | 8.3 |
| | | 16 | 52.9 | 10 | | 12 | 15 | 56.1 | 7.5 |
| 3 | 6 | 10 | 70.7 | 18 | ½ | 7 | 9 | 38.7 | 18.4 |
| | | 12 | 71.1 | 16 | | 9 | 11 | 49.7 | 16.3 |
| | | 14 | 71.4 | 14 | | 10 | 13 | 55.2 | 14.3 |
| | | 16 | 71.7 | 12 | | 13 | 16 | 71.8 | 12.3 |
| 4 | 0 | 10 | 91.4 | 23 | ½ | 7 | 9 | 44.6 | 30.7 |
| | | 12 | 92.2 | 19 | | 10 | 12 | 63.7 | 25.3 |
| | | 14 | 92.6 | 17 | | 10 | 13 | 63.7 | 22.7 |
| | | 16 | 93.0 | 15 | | 12 | 16 | 76.5 | 20.0 |
| | | 18 | 93.2 | 14 | | 13 | 17 | 82.9 | 18.7 |
| | | 20 | 93.4 | 13 | | 14 | 18 | 89.2 | 17.3 |
| 4 | 6 | 10 | 114.7 | 27 | ½ | 7 | 9 | 50.6 | 45.6 |
| | | 12 | 115.7 | 23 | | 9 | 11 | 65.0 | 38.8 |
| | | 14 | 116.2 | 21 | | 10 | 13 | 72.2 | 35.5 |
| | | 16 | 116.9 | 18 | | 12 | 16 | 86.7 | 30.4 |
| | | 18 | 117.2 | 17 | | 13 | 16 | 94.0 | 28.7 |
| | | 20 | 117.7 | 15 | | 15 | 19 | 108.0 | 25.3 |
| 5 | 0 | 12 | 141.2 | 28 | ½ | 8 | 11 | 64.6 | 58.3 |
| | | 14 | 142.2 | 25 | | 10 | 12 | 80.7 | 52.1 |
| | | 16 | 143.1 | 22 | | 12 | 15 | 97.0 | 45.8 |
| | | 18 | 143.7 | 20 | | 13 | 16 | 105 | 41.7 |
| | | 20 | 144.4 | 18 | | 15 | 19 | 121 | 37.5 |
| | | 22 | 145.0 | 16 | | 16 | 22 | 129 | 33.3 |
| 5 | 6 | 12 | 169.0 | 33 | ½ | 8 | 11 | 71.4 | 83.2 |
| | | 14 | 170.5 | 29 | | 10 | 12 | 89.2 | 73.1 |
| | | 16 | 172.0 | 25 | | 13 | 16 | 116.0 | 63.0 |
| | | 18 | 172.8 | 23 | | 13 | 17 | 116 | 58.0 |
| | | 20 | 173.6 | 21 | | 15 | 19 | 134 | 52.9 |
| | | 22 | 174.3 | 19 | | 17 | 21 | 152 | 47.9 |
| 6 | 0 | 12 | 198.9 | 38 | ½ | 8 | 11 | 78.2 | 114.0 |
| | | 14 | 201.2 | 33 | | 10 | 12 | 97.8 | 99.0 |
| | | 16 | 202.5 | 30 | | 11 | 14 | 108 | 90.0 |
| | | 18 | 203.8 | 27 | | 13 | 16 | 127 | 81.0 |
| | | 20 | 205.2 | 24 | | 15 | 19 | 147 | 72.0 |
| | | 22 | 206.1 | 22 | | 17 | 21 | 166 | 66.0 |
| | | 24 | 207.0 | 20 | | 19 | 24 | 186 | 60.0 |
| | | 26 | 207.4 | 19 | | 20 | 25 | 195 | 57.0 |
| 6 | 6 | 12 | 230.8 | 43 | ½ | 9 | 11 | 95.7 | 152.0 |
| | | 14 | 233.5 | 38 | | 10 | 12 | 106 | 134.0 |
| | | 16 | 235.6 | 34 | | 11 | 14 | 117 | 120.0 |
| | | 18 | 237.7 | 30 | | 13 | 17 | 138 | 106.0 |
| | | 20 | 238.7 | 28 | | 14 | 18 | 149 | 98.5 |
| | | 22 | 240.3 | 25 | | 17 | 21 | 181 | 88.0 |
| | | 24 | 241.4 | 23 | | 18 | 23 | 192 | 81.0 |
| | | 26 | 241.9 | 22 | | 19 | 24 | 202 | 77.4 |



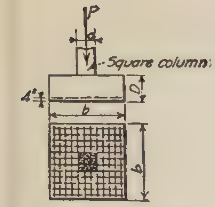
## DESIGN OF SINGLE SQUARE FOOTINGS

## 3 TONS ON SOIL

*Punching shear = 120*
*Bond stress = 100*
*Tension in steel = 16,000*

| Footing size $b$ | | Column size $a$ (in.) | Allowable load $P$ (thousands of pounds) | Total depth $D$ (in.) | Steel | | | | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| (ft.) | (in.) | | | | Size (in.) | No. rods each way | | Weight of sq. rods (lb.) | |
| | | | | | | Square | Round | | |
| 7 | 0 | 14 | 267.7 | 43 | ½ | 11 | 14 | 121 | 176 |
| | | 16 | 270.2 | 39 | | 12 | 15 | 138 | 159 |
| | | 18 | 272.6 | 35 | | 13 | 16 | 149 | 143 |
| | | 20 | 275.0 | 31 | | 15 | 19 | 172 | 126 |
| | | 22 | 276.3 | 29 | | 16 | 20 | 184 | 118 |
| | | 24 | 277.5 | 27 | | 18 | 22 | 207 | 110 |
| | | 26 | 278.7 | 25 | | 19 | 24 | 218 | 102 |
| | | 28 | 279.9 | 23 | | 21 | 27 | 241 | 94 |
| 7 | 6 | 14 | 303.7 | 48 | ½ | 12 | 15 | 148 | 225 |
| | | 16 | 307.4 | 43 | | 13 | 16 | 160 | 202 |
| | | 18 | 310.0 | 39 | | 14 | 18 | 173 | 183 |
| | | 20 | 312.9 | 35 | | 16 | 20 | 197 | 164 |
| | | 22 | 315.0 | 32 | | 17 | 22 | 210 | 150 |
| | | 24 | 316.3 | 30 | | 18 | 22 | 222 | 141 |
| | | 26 | 317.8 | 28 | | 19 | 24 | 234 | 131 |
| | | 28 | 319.2 | 26 | | 21 | 27 | 257 | 122 |
| 8 | 0 | 16 | 345.6 | 48 | ½ | 14 | 17 | 185 | 256 |
| | | 18 | 349.6 | 43 | | 15 | 19 | 198 | 229 |
| | | 20 | 352.8 | 39 | | 17 | 21 | 224 | 208 |
| | | 22 | 355.2 | 36 | | 18 | 23 | 237 | 192 |
| | | 24 | 357.6 | 33 | | 20 | 25 | 264 | 176 |
| | | 26 | 359.2 | 31 | | 21 | 26 | 277 | 165 |
| | | 28 | 360.7 | 29 | | 21 | 27 | 277 | 155 |
| | | 30 | 362.4 | 27 | | 23 | 29 | 303 | 144 |
| 8 | 6 | 16 | 386.6 | 53 | ½ | 15 | 19 | 211 | 319 |
| | | 18 | 390.1 | 48 | | 16 | 21 | 224 | 289 |
| | | 20 | 393.7 | 44 | | 18 | 22 | 252 | 265 |
| | | 22 | 397.3 | 40 | | 19 | 24 | 266 | 241 |
| | | 24 | 400.1 | 37 | | 21 | 27 | 294 | 223 |
| | | 26 | 401.9 | 35 | | 22 | 28 | 309 | 211 |
| | | 28 | 404.5 | 32 | | 24 | 30 | 337 | 193 |
| | | 30 | 406.3 | 30 | | 25 | 32 | 351 | 181 |
| 9 | 0 | 18 | 432.2 | 53 | ⅝ | 11 | 14 | 256 | 358 |
| | | 20 | 437.3 | 48 | | 12 | 15 | 279 | 324 |
| | | 22 | 441.4 | 44 | | 13 | 17 | 302 | 297 |
| | | 24 | 444.4 | 41 | | 14 | 18 | 325 | 277 |
| | | 26 | 447.4 | 38 | | 15 | 20 | 349 | 257 |
| | | 28 | 449.5 | 36 | | 16 | 21 | 372 | 243 |
| | | 30 | 452.5 | 33 | | 18 | 23 | 418 | 223 |
| | | 32 | 454.6 | 31 | | 20 | 25 | 465 | 209 |
| | | 34 | 456.6 | 29 | | 21 | 27 | 488 | 196 |
| 9 | 6 | 18 | 476.1 | 58 | ⅝ | 12 | 15 | 295 | 436 |
| | | 20 | 481.6 | 53 | | 13 | 16 | 319 | 399 |
| | | 22 | 486.1 | 49 | | 14 | 18 | 344 | 369 |
| | | 24 | 490.6 | 45 | | 15 | 19 | 369 | 339 |
| | | 26 | 494.1 | 42 | | 16 | 21 | 393 | 316 |
| | | 28 | 497.5 | 39 | | 17 | 22 | 418 | 293 |
| | | 30 | 499.8 | 37 | | 18 | 23 | 442 | 278 |
| | | 32 | 502.0 | 35 | | 19 | 24 | 467 | 263 |
| | | 34 | 504.3 | 33 | | 20 | 26 | 492 | 248 |

TABLE 50



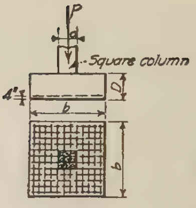
## DESIGN OF SINGLE SQUARE FOOTINGS

## 3 TONS ON SOIL

***Punching shear = 120***
***Bond stress = 100***
***Tension in steel = 16,000***

| Footing size $b$ | | Column size $a$ (in.) | Allowable load $P$ (thousands of pounds) | Total depth $D$ (in.) | Steel | | | | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Size (in.) | No. rods each way | | Weight of sq. rods (lb.) | |
| (ft.) | (in.) | | | | | Square | Round | | |
| 10 | 0 | 18 | 521.3 | 63 | ⅝ | 13 | 16 | 336 | 525 |
| | | 20 | 527.5 | 58 | | 14 | 17 | 362 | 483 |
| | | 22 | 533.7 | 53 | | 15 | 19 | 388 | 442 |
| | | 24 | 538.9 | 49 | | 16 | 20 | 414 | 408 |
| | | 26 | 542.5 | 46 | | 17 | 22 | 440 | 383 |
| | | 28 | 546.3 | 43 | | 18 | 23 | 465 | 358 |
| | | 30 | 550.0 | 40 | | 19 | 25 | 492 | 333 |
| | | 32 | 552.5 | 38 | | 20 | 25 | 518 | 317 |
| | | 34 | 555.0 | 36 | | 21 | 27 | 544 | 300 |
| | | 36 | 557.5 | 34 | | 22 | 28 | 569 | 283 |
| 10 | 6 | 18 | 566.3 | 69 | ⅝ | 14 | 17 | 381 | 634 |
| | | 20 | 574.5 | 63 | | 15 | 18 | 408 | 579 |
| | | 22 | 581.5 | 58 | | 16 | 20 | 435 | 533 |
| | | 24 | 587.1 | 54 | | 17 | 21 | 463 | 496 |
| | | 26 | 593.2 | 50 | | 18 | 23 | 490 | 456 |
| | | 28 | 596.6 | 47 | | 19 | 24 | 517 | 432 |
| | | 30 | 600.8 | 44 | | 20 | 26 | 544 | 404 |
| | | 32 | 604.9 | 41 | | 22 | 28 | 599 | 377 |
| | | 34 | 608.8 | 39 | | 23 | 29 | 626 | 358 |
| | | 36 | 610.5 | 37 | | 23 | 30 | 626 | 340 |
| | | 38 | 613.2 | 35 | | 24 | 31 | 653 | 322 |
| 11 | 0 | 20 | 623.2 | 68 | ⅝ | 15 | 20 | 458 | 686 |
| | | 22 | 630.8 | 63 | | 17 | 21 | 486 | 635 |
| | | 24 | 638.3 | 58 | | 18 | 22 | 515 | 585 |
| | | 26 | 644.4 | 54 | | 19 | 24 | 543 | 544 |
| | | 28 | 648.9 | 51 | | 20 | 25 | 582 | 514 |
| | | 30 | 653.4 | 48 | | 21 | 27 | 600 | 484 |
| | | 32 | 657.9 | 45 | | 23 | 29 | 658 | 454 |
| | | 34 | 662.5 | 42 | | 24 | 31 | 686 | 423 |
| | | 36 | 665.5 | 40 | | 25 | 32 | 715 | 403 |
| | | 38 | 668.5 | 38 | | 26 | 33 | 743 | 383 |
| | | 40 | 671.5 | 36 | | 27 | 34 | 772 | 363 |
| 11 | 6 | 20 | 672.9 | 73 | ⅝ | 16 | 21 | 478 | 804 |
| | | 22 | 682.8 | 67 | | 18 | 23 | 538 | 738 |
| | | 24 | 689.5 | 63 | | 19 | 24 | 568 | 694 |
| | | 26 | 696.0 | 59 | | 20 | 25 | 598 | 650 |
| | | 28 | 702.6 | 55 | | 21 | 27 | 628 | 606 |
| | | 30 | 709.1 | 51 | | 23 | 29 | 687 | 562 |
| | | 32 | 714.1 | 48 | | 24 | 31 | 717 | 529 |
| | | 34 | 717.5 | 46 | | 25 | 32 | 747 | 507 |
| | | 36 | 722.3 | 43 | | 26 | 34 | 777 | 474 |
| | | 38 | 725.7 | 41 | | 27 | 35 | 807 | 452 |
| | | 40 | 729.1 | 39 | | 28 | 36 | 837 | 429 |
| | | 42 | 732.3 | 37 | | 29 | 37 | 866 | 408 |
| 12 | 0 | 22 | 734.4 | 72 | ⅝ | 19 | 24 | 593 | 864 |
| | | 24 | 743.4 | 67 | | 20 | 25 | 614 | 804 |
| | | 26 | 750.6 | 63 | | 21 | 27 | 655 | 756 |
| | | 28 | 757.8 | 59 | | 22 | 28 | 686 | 708 |
| | | 30 | 765.0 | 55 | | 24 | 31 | 748 | 660 |
| | | 32 | 770.4 | 52 | | 25 | 32 | 780 | 624 |
| | | 34 | 775.8 | 49 | | 27 | 34 | 842 | 588 |
| | | 36 | 779.4 | 47 | | 27 | 35 | 842 | 564 |
| | | 38 | 784.8 | 44 | | 29 | 37 | 904 | 528 |
| | | 40 | 788.4 | 42 | | 30 | 38 | 936 | 504 |
| | | 42 | 792.0 | 40 | | 31 | 39 | 967 | 480 |
| | | 44 | 793.8 | 39 | | 31 | 39 | 967 | 468 |

## FOOTINGS



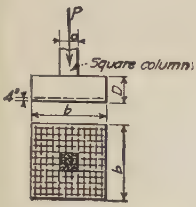
# DESIGN OF SINGLE SQUARE FOOTINGS

## 4 TONS ON SOIL

***Punching shear = 120***
***Bond stress = 100***
***Tension in steel = 16,000***

| Footing size *b* (ft.) | Footing size *b* (in.) | Column size *a* (in.) | Allowable load *P* (thousands of pounds) | Total depth *D* (in.) | Steel: Size (in.) | Steel: No. rods each way, Square | Steel: No. rods each way, Round | Steel: Weight of sq. rods (lb.) | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 0 | 10 | 70.0 | 18 | ½ | 7 | 9 | 32.8 | 13.5 |
| | | 12 | 70.3 | 15 | | 9 | 11 | 42.0 | 11.3 |
| | | 14 | 70.5 | 13 | | 10 | 13 | 46.7 | 9.8 |
| | | 16 | 70.6 | 12 | | 11 | 14 | 51.5 | 9.0 |
| | | 18 | 70.8 | 11 | | 12 | 15 | 56.1 | 8.3 |
| 3 | 6 | 10 | 94.5 | 23 | ½ | 7 | 9 | 38.7 | 23.5 |
| | | 12 | 94.9 | 20 | | 8 | 10 | 44.2 | 20.4 |
| | | 14 | 95.4 | 17 | | 10 | 12 | 55.2 | 17.4 |
| | | 16 | 95.7 | 15 | | 11 | 15 | 60.7 | 15.3 |
| | | 18 | 95.9 | 14 | | 12 | 15 | 66.3 | 14.3 |
| | | 20 | 96.2 | 12 | | 15 | 19 | 82.9 | 12.3 |
| 4 | 0 | 10 | 122.2 | 29 | ½ | 7 | 9 | 44.6 | 38.7 |
| | | 12 | 123.0 | 25 | | 8 | 10 | 51.0 | 33.3 |
| | | 14 | 123.8 | 21 | | 10 | 12 | 63.7 | 28.0 |
| | | 16 | 124.1 | 19 | | 11 | 14 | 70.1 | 25.3 |
| | | 18 | 124.6 | 17 | | 13 | 16 | 82.9 | 22.7 |
| | | 20 | 125.0 | 15 | | 15 | 19 | 95.6 | 20.0 |
| | | 22 | 125.3 | 14 | | 15 | 19 | 95.6 | 18.7 |
| 4 | 6 | 10 | 153.1 | 35 | ½ | 7 | 9 | 50.6 | 59.0 |
| | | 12 | 154.4 | 30 | | 8 | 10 | 57.7 | 50.6 |
| | | 14 | 155.4 | 26 | | 10 | 12 | 72.2 | 43.8 |
| | | 16 | 156.2 | 23 | | 11 | 14 | 79.5 | 38.8 |
| | | 18 | 156.7 | 21 | | 12 | 15 | 86.7 | 35.4 |
| | | 20 | 157.2 | 19 | | 14 | 17 | 101.0 | 32.0 |
| | | 22 | 157.7 | 17 | | 16 | 20 | 116.0 | 28.7 |
| 5 | 0 | 12 | 188.7 | 36 | ½ | 8 | 11 | 64.6 | 75.0 |
| | | 14 | 190.3 | 31 | | 10 | 12 | 80.7 | 64.6 |
| | | 16 | 191.6 | 27 | | 11 | 14 | 88.8 | 56.2 |
| | | 18 | 192.2 | 25 | | 12 | 15 | 97.0 | 52.1 |
| | | 20 | 193.1 | 22 | | 14 | 18 | 113 | 45.8 |
| | | 22 | 193.7 | 20 | | 16 | 20 | 129 | 41.7 |
| | | 24 | 194.1 | 19 | | 17 | 21 | 137 | 39.6 |
| 5 | 6 | 12 | 226.1 | 42 | ½ | 9 | 11 | 80.2 | 106.0 |
| | | 14 | 228.0 | 37 | | 10 | 12 | 89.2 | 93.2 |
| | | 16 | 229.9 | 32 | | 11 | 14 | 98.2 | 80.7 |
| | | 18 | 231.0 | 29 | | 13 | 16 | 116 | 73.1 |
| | | 20 | 232.2 | 26 | | 14 | 18 | 125 | 65.5 |
| | | 22 | 232.9 | 24 | | 15 | 19 | 134 | 60.5 |
| | | 24 | 233.7 | 22 | | 17 | 22 | 152 | 55.4 |
| | | 26 | 234.4 | 20 | | 19 | 24 | 170 | 50.4 |
| 6 | 0 | 14 | 268.6 | 43 | ½ | 9 | 12 | 88.0 | 129.0 |
| | | 16 | 270.6 | 38 | | 11 | 14 | 108 | 116.0 |
| | | 18 | 272.7 | 34 | | 12 | 16 | 117 | 102.0 |
| | | 20 | 274.0 | 31 | | 14 | 17 | 137 | 93.0 |
| | | 22 | 275.4 | 28 | | 15 | 19 | 147 | 84.0 |
| | | 24 | 276.3 | 26 | | 17 | 21 | 166 | 78.0 |
| | | 26 | 277.2 | 24 | | 18 | 23 | 176 | 72.0 |
| | | 28 | 278.1 | 22 | | 20 | 26 | 195 | 66.0 |
| 6 | 6 | 14 | 312.1 | 49 | ½ | 10 | 13 | 106 | 172.0 |
| | | 16 | 314.7 | 44 | | 11 | 14 | 117 | 155.0 |
| | | 18 | 317.5 | 39 | | 13 | 16 | 138 | 137.0 |
| | | 20 | 319.5 | 35 | | 14 | 18 | 149 | 123.0 |
| | | 22 | 321.1 | 32 | | 15 | 19 | 160 | 112.0 |
| | | 24 | 322.2 | 30 | | 17 | 21 | 181 | 106.0 |
| | | 26 | 323.2 | 28 | | 18 | 23 | 192 | 98.5 |
| | | 28 | 324.3 | 26 | ½ | 19 | 25 | 202 | 91.5 |
| | | 30 | 325.3 | 24 | | 21 | 27 | 223 | 84.5 |

TABLE 51

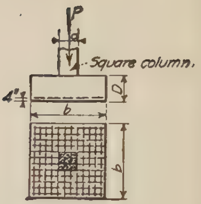


## DESIGN OF SINGLE SQUARE FOOTINGS

## 4 TONS ON SOIL

*Punching shear = 120*
*Bond stress = 100*
*Tension in steel = 16,000*

| Footing size *b* (ft.) | Footing size *b* (in.) | Column size *a* (in.) | Allowable load *P* (thousands of pounds) | Total depth *D* (in.) | Steel: Size (in.) | Steel: No. rods each way: Square | Steel: No. rods each way: Round | Steel: Weight of sq. rods (lb.) | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 0 | 16 | 361.4 | 50 | ½ | 12 | 15 | 138 | 204 |
| | | 18 | 364.4 | 45 | | 13 | 16 | 149 | 184 |
| | | 20 | 367.5 | 40 | | 14 | 18 | 161 | 163 |
| | | 22 | 369.3 | 37 | | 15 | 19 | 172 | 151 |
| | | 24 | 371.1 | 34 | | 17 | 21 | 195 | 139 |
| | | 26 | 372.4 | 32 | | 18 | 22 | 207 | 131 |
| | | 28 | 374.2 | 29 | | 20 | 25 | 230 | 118 |
| | | 30 | 375.4 | 27 | | 22 | 27 | 252 | 110 |
| | | 32 | 376.7 | 25 | | 25 | 30 | 287 | 102 |
| 7 | 6 | 16 | 410.6 | 55 | ½ | 13 | 16 | 160 | 263 |
| | | 18 | 414.2 | 51 | | 14 | 17 | 173 | 239 |
| | | 20 | 417.7 | 46 | | 15 | 19 | 185 | 215 |
| | | 22 | 420.4 | 42 | | 16 | 20 | 197 | 197 |
| | | 24 | 422.5 | 39 | | 16 | 21 | 197 | 183 |
| | | 26 | 424.7 | 36 | | 18 | 22 | 222 | 168 |
| | | 28 | 426.8 | 33 | | 20 | 25 | 246 | 155 |
| | | 30 | 428.2 | 31 | | 21 | 27 | 259 | 145 |
| | | 32 | 429.6 | 29 | | 23 | 29 | 284 | 136 |
| | | 34 | 431.0 | 27 | | 25 | 31 | 308 | 126 |
| 8 | 0 | 18 | 466.4 | 57 | ½ | 15 | 19 | 198 | 304 |
| | | 20 | 471.2 | 51 | | 16 | 21 | 211 | 272 |
| | | 22 | 474.3 | 47 | | 17 | 22 | 224 | 251 |
| | | 24 | 477.6 | 43 | | 18 | 23 | 237 | 229 |
| | | 26 | 480.0 | 40 | | 19 | 24 | 250 | 213 |
| | | 28 | 482.4 | 37 | | 20 | 25 | 264 | 197 |
| | | 30 | 484.0 | 35 | | 21 | 26 | 277 | 187 |
| | | 32 | 485.6 | 33 | | 22 | 28 | 290 | 176 |
| | | 34 | 487.2 | 31 | | 24 | 30 | 316 | 165 |
| | | 36 | 488.8 | 29 | | 26 | 32 | 343 | 155 |
| 8 | 6 | 18 | 521.0 | 63 | ½ | 16 | 20 | 224 | 380 |
| | | 20 | 526.5 | 57 | | 17 | 22 | 238 | 343 |
| | | 22 | 531.0 | 52 | | 19 | 24 | 266 | 313 |
| | | 24 | 534.6 | 48 | | 20 | 25 | 281 | 289 |
| | | 26 | 537.3 | 45 | | 21 | 26 | 294 | 271 |
| | | 28 | 540.0 | 42 | | 21 | 27 | 294 | 253 |
| | | 30 | 542.7 | 39 | | 22 | 28 | 309 | 235 |
| | | 32 | 545.4 | 36 | | 24 | 31 | 337 | 217 |
| | | 34 | 557.2 | 34 | | 25 | 31 | 351 | 205 |
| | | 36 | 549.0 | 32 | | 26 | 33 | 365 | 193 |
| 9 | 0 | 20 | 584.2 | 63 | ⅝ | 12 | 15 | 279 | 425 |
| | | 22 | 589.4 | 58 | | 13 | 16 | 302 | 391 |
| | | 24 | 593.3 | 54 | | 13 | 17 | 302 | 364 |
| | | 26 | 598.3 | 49 | | 15 | 19 | 349 | 331 |
| | | 28 | 601.4 | 46 | | 16 | 20 | 372 | 310 |
| | | 30 | 604.4 | 43 | | 17 | 21 | 395 | 290 |
| | | 32 | 607.5 | 40 | | 18 | 23 | 418 | 270 |
| | | 34 | 609.6 | 38 | | 19 | 24 | 442 | 256 |
| | | 36 | 611.5 | 36 | | 20 | 26 | 465 | 243 |
| | | 38 | 613.6 | 34 | | 22 | 28 | 511 | 229 |
| 9 | 6 | 20 | 644.1 | 69 | ⅝ | 13 | 16 | 319 | 519 |
| | | 22 | 649.9 | 64 | | 14 | 18 | 344 | 481 |
| | | 24 | 655.5 | 59 | | 14 | 18 | 344 | 443 |
| | | 26 | 660.0 | 55 | | 15 | 19 | 369 | 413 |
| | | 28 | 664.5 | 51 | | 16 | 20 | 393 | 383 |
| | | 30 | 667.8 | 48 | | 16 | 21 | 393 | 361 |
| | | 32 | 671.3 | 45 | | 17 | 22 | 418 | 338 |
| | | 34 | 674.6 | 42 | | 19 | 24 | 467 | 316 |
| | | 36 | 676.8 | 40 | | 20 | 26 | 491 | 301 |
| | | 38 | 679.1 | 38 | | 21 | 27 | 516 | 286 |
| | | 40 | 681.3 | 36 | | 23 | 29 | 565 | 271 |



## DESIGN OF SINGLE SQUARE FOOTINGS
## 4 TONS ON SOIL

***Punching shear* = 120**
***Bond stress* = 100**
***Tension in steel* = 16,000**

| Footing size b (ft.) | Footing size b (in.) | Column size a (in.) | Allowable load P (thousands of pounds) | Total depth D (in.) | Steel Size (in.) | Steel No. rods each way Square | Steel No. rods each way Round | Steel Weight of sq. rods (lb.) | Volume of concrete (cu. ft.) |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 0 | 22 | 712.5 | 70 | ⅝ | 15 | 19 | 388 | 583 |
| | | 24 | 718.8 | 65 | | 15 | 19 | 388 | 541 |
| | | 26 | 725.0 | 60 | | 17 | 21 | 440 | 500 |
| | | 28 | 730.0 | 56 | | 17 | 22 | 440 | 467 |
| | | 30 | 735.0 | 52 | | 18 | 23 | 466 | 433 |
| | | 32 | 738.8 | 49 | | 19 | 24 | 492 | 408 |
| | | 34 | 742.5 | 46 | | 20 | 25 | 518 | 383 |
| | | 36 | 745.0 | 44 | | 20 | 25 | 518 | 367 |
| | | 38 | 748.7 | 41 | | 22 | 28 | 569 | 342 |
| | | 40 | 751.2 | 39 | | 23 | 29 | 595 | 325 |
| | | 42 | 753.8 | 37 | | 24 | 31 | 620 | 308 |
| 10 | 6 | 22 | 777.3 | 76 | ⅝ | 16 | 20 | 435 | 698 |
| | | 24 | 785.5 | 70 | | 17 | 21 | 462 | 643 |
| | | 26 | 792.5 | 65 | | 18 | 22 | 490 | 597 |
| | | 28 | 797.9 | 61 | | 18 | 23 | 490 | 561 |
| | | 30 | 803.3 | 57 | | 19 | 24 | 517 | 524 |
| | | 32 | 807.7 | 54 | | 20 | 25 | 544 | 496 |
| | | 34 | 811.6 | 51 | | 20 | 26 | 544 | 469 |
| | | 36 | 815.9 | 48 | | 21 | 27 | 571 | 441 |
| | | 38 | 820.0 | 45 | | 23 | 29 | 626 | 413 |
| | | 40 | 822.7 | 43 | | 23 | 29 | 626 | 395 |
| | | 42 | 825.4 | 41 | | 24 | 31 | 663 | 377 |
| | | 44 | 828.3 | 39 | | 25 | 32 | 680 | 358 |
| 11 | 0 | 24 | 853.0 | 76 | ⅝ | 18 | 22 | 515 | 766 |
| | | 26 | 860.6 | 71 | | 19 | 24 | 543 | 716 |
| | | 28 | 868.2 | 66 | | 20 | 25 | 572 | 665 |
| | | 30 | 874.2 | 62 | | 21 | 26 | 600 | 625 |
| | | 32 | 880.2 | 58 | | 21 | 27 | 600 | 585 |
| | | 34 | 884.8 | 55 | | 22 | 28 | 629 | 554 |
| | | 36 | 889.4 | 52 | | 23 | 29 | 658 | 524 |
| | | 38 | 893.8 | 49 | | 24 | 30 | 686 | 494 |
| | | 40 | 896.8 | 47 | | 24 | 31 | 686 | 474 |
| | | 42 | 900.0 | 45 | | 25 | 32 | 715 | 453 |
| | | 44 | 903.0 | 43 | | 25 | 32 | 715 | 433 |
| | | 46 | 906.0 | 41 | | 26 | 33 | 743 | 413 |
| 11 | 6 | 24 | 922.4 | 82 | ⅝ | 19 | 24 | 568 | 903 |
| | | 26 | 931.0 | 77 | | 20 | 25 | 598 | 848 |
| | | 28 | 940.8 | 71 | | 21 | 27 | 628 | 782 |
| | | 30 | 947.4 | 67 | | 22 | 28 | 657 | 738 |
| | | 32 | 954.0 | 63 | | 23 | 29 | 687 | 694 |
| | | 34 | 958.9 | 60 | | 23 | 30 | 687 | 661 |
| | | 36 | 963.8 | 57 | | 24 | 30 | 717 | 628 |
| | | 38 | 968.8 | 54 | | 25 | 31 | 747 | 595 |
| | | 40 | 973.7 | 51 | | 26 | 33 | 777 | 562 |
| | | 42 | 977.0 | 49 | | 26 | 33 | 777 | 540 |
| | | 44 | 982.0 | 46 | | 28 | 35 | 837 | 507 |
| | | 46 | 985.2 | 44 | | 29 | 36 | 866 | 485 |
| | | 48 | 988.7 | 42 | | 29 | 37 | 866 | 462 |
| 12 | 0 | 26 | 1002.7 | 83 | ⅝ | 21 | 26 | 655 | 996 |
| | | 28 | 1013.3 | 77 | | 22 | 28 | 686 | 925 |
| | | 30 | 1022.2 | 72 | | 23 | 29 | 717 | 865 |
| | | 32 | 1029.6 | 68 | | 24 | 30 | 748 | 816 |
| | | 34 | 1036.8 | 64 | | 25 | 32 | 780 | 768 |
| | | 36 | 1042.3 | 61 | | 26 | 32 | 811 | 732 |
| | | 38 | 1047.5 | 58 | | 26 | 34 | 811 | 697 |
| | | 40 | 1053.0 | 55 | | 27 | 35 | 842 | 660 |
| | | 42 | 1058.4 | 52 | | 29 | 36 | 905 | 624 |
| | | 44 | 1062.0 | 50 | | 29 | 37 | 905 | 600 |
| | | 46 | 1065.6 | 48 | | 30 | 38 | 936 | 576 |
| | | 48 | 1069.2 | 46 | | 30 | 39 | 936 | 552 |
| | | 50 | 1073.8 | 44 | | 31 | 40 | 967 | 528 |

## SECTION 10

## MISCELLANEOUS

**Estimates.**—Estimates of the cost of the concrete work for buildings and similar structures can be easily made by applying current unit costs to the quantities obtained from the tables and diagrams.

Diagram 66 gives the quantities of concrete, steel and forms for typical square panels of a three beam and girder floor system. Although the quantities of steel or concrete may be somewhat affected by changing the proportions of beams or girders, the total cost will vary only slightly. Quantities for flat slab floors may be found in Section 2.

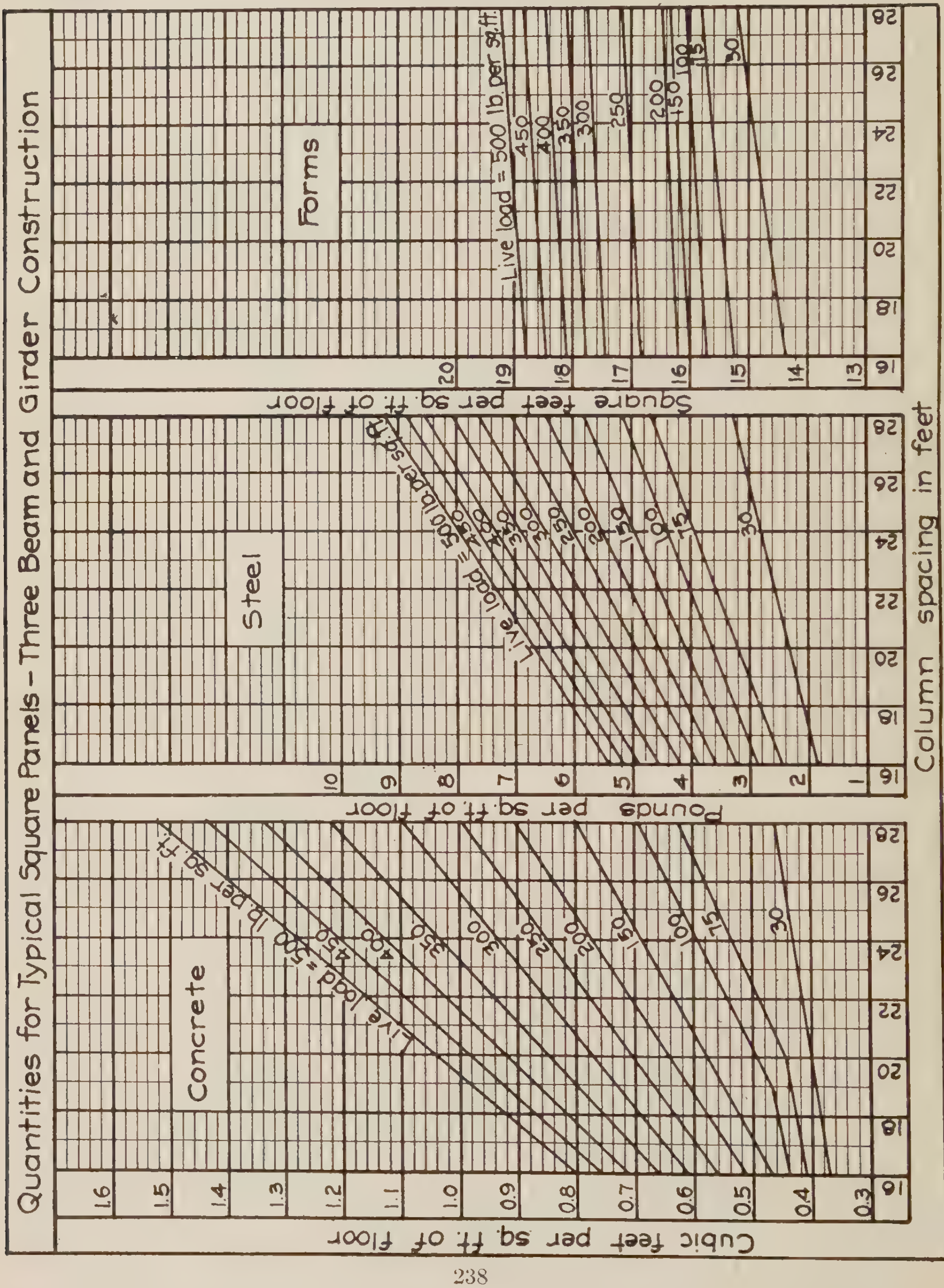
By means of Diagrams 42 and 43 of Section 7, which give weights of floor panels, the column and footing loads can be quickly estimated and the quantities taken from the column and footing tables.

**Loads.**—Tables 52, 53 and 54, give the building code requirements for live load, weights of contents of storage warehouses, and weights of building materials respectively.

# APPROXIMATE QUANTITIES OF CONCRETE, STEEL AND FORMS FOR TYPICAL SQUARE INTERIOR PANELS OF THREE BEAM AND GIRDER FLOOR SYSTEM DESIGNED IN ACCORDANCE WITH JOINT COMMITTEE RECOMMENDATIONS

(COLUMNS NOT INCLUDED)

$f_c = 650$
$f_s = 16{,}000$



## BUILDING CODE REQUIREMENTS FOR LIVE LOAD

| Structure | Baltimore | Boston | Buffalo | Chicago | Cincinnati | Indianapolis | Milwaukee | Minneapolis | New Orleans | New York | Philadelphia | Pittsburgh | St. Louis | San Francisco | Seattle | Washington |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apartments | 60 | 50 | 70 | 40 | 40 | 50 | 30 | 50 | 40 | ... | 70 | ... | 50 | 60 | 40 | 50 |
| Public rooms and halls | ... | 100 | ... | 100 | ... | ... | ... | ... | 70 | ... | ... | ... | ... | ... | ... | 75 |
| Assembly halls | ... | ... | 100 | 100 | 100 | 125 | ... | 125 | ... | 100 | 120 | 150 | 100 | | | |
| Fxd. seat auditoriums | 75 | ... | ... | 100 | ... | .. | 50 | ... | ... | ... | ... | ... | ... | 75 | 75 | |
| Mov. seat auditoriums | 125 | ... | ... | .. | ... | .. | 80 | ... | ... | ... | ... | ... | ... | 125 | 100 | |
| Churches | ... | ... | 100 | 100 | .. | 125 | 50 | ... | ... | ... | ... | ... | 75 | ... | 75 | |
| Dance halls | ... | 200 | ... | 100 | 150 | ... | 100 | ... | 150 | ... | ... | ... | ... | ... | 100 | |
| Drill rooms | ... | 200 | ... | ... | ... | ... | 100 | ... | 150 | ... | ... | ... | ... | ... | 250 | |
| Theaters | ... | ... | 100 | 100 | 100 | 125 | 50 | ... | ... | ... | ... | ... | 100 | 75 | 75 | |
| Theater balconies | | | | | | | | | | | | | | | | |
| Theater stairways | ... | ... | ... | ... | ... | ... | 80 | ... | ... | ... | ... | ... | ... | ... | 100 | |
| Dwellings | 60 | 50 | 40 | 40 | 40 | 50 | 30 | 50 | 40 | 40 | 70 | 70 | 50 | 60 | 40 | 50 |
| Hospitals | ... | ... | 70 | 50 | ... | 50 | 30 | 50 | ... | ... | 70 | ... | 50 | 60 | 50 | |
| Hotels | 60 | ... | 70 | 50 | 40 | 75 | 30 | 50 | 40 | ... | 70 | ... | 50 | 60 | 40 | 50 |
| First floors | ... | ... | ... | ... | 100 | ... | ... | ... | ... | .. | ... | ... | ... | ... | 100 | 75 |
| Corridors | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 125 | 100 | 75 |
| Office rooms | ... | ... | ... | 50 | ... | ... | .. | ... | ... | ... | ... | ... | ... | ... | ... | 75 |
| Manufacturing | 175 | ... | ... | ... | 150 | 200 | ... | ... | ... | ... | 150 | 200 | 150 | 250 | | |
| Light manufacturing | 125 | 125 | 120 | 100 | 100 | 100 | 100 | 100 | 125 | ... | 120 | ... | 100 | 125 | 125 | |
| Mercantile | 125 | 250 | ... | 100 | ... | ... | ... | ... | 200 | ... | ... | ... | 150 | | | |
| Retail stores | 125 | 125 | 120 | 100 | 100 | 100 | 100 | 100 | 125 | 120 | 120 | ... | 150 | 125 | 125 | 110 |
| Heavy storehouses | 250 | 250 | ... | ... | 150 | 200 | ... | ... | ... | ... | 150 | ... | .. | 250 | ... | 150 |
| Warehouses | ... | 250 | 150 | ... | 150 | 200 | ... | ... | 200 | ... | 150 | 200 | 150 | 250 | ... | 150 |
| Offices | 75 | 100 | 70 | 50 | 50 | 75 | 40 | 75 | 70 | 60 | 100 | ... | 60 | 60 | 50 | 75 |
| First floor | 150 | ... | ... | ... | 100 | 150 | 80 | 100 | ... | ... | ... | ... | 100 | ... | 125 | |
| Corridors | ... | .. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 100 | ... | ... | 110 |
| Public buildings | ... | .. | ... | ... | 100 | ... | ... | ... | 125 | ... | ... | ... | 100 | ... | ... | 110 |
| Schools—class rooms | 75 | 60 | ... | ... | 60 | 100 | 40 | 100 | 60 | 75 | ... | ... | 75 | 75 | 50 | 75 |
| Assembly rooms | ... | 125 | 100 | 75 | ... | ... | 60 | ... | 125 | ... | ... | ... | ... | ... | 75 | |
| Corridors | ... | ... | ... | ... | ... | ... | 60 | ... | ... | ... | ... | ... | ... | 125 | 100 | |
| Stairways | ... | ... | ... | ... | ... | ... | 60 | | | | | | | | | |
| Sidewalks | 200 | ... | ... | ... | 300 | 300 | 150 | 300 | 300 | 300 | ... | ... | ... | 150 | | |
| Stables, carriage houses, garages | 100 | .. | 120 | 100 | 75 | 85 | 80 | 85 | ... | ... | ... | .. | 100 | 75 | 75 | |
| Stairways, general | ... | 70 | ... | 100 | 80 | ... | 60 | ... | 70 | ... | ... | ... | ... | ... | 100 | |
| Fire escapes | ... | 70 | ... | ... | ... | ... | ... | ... | 70 | ... | ... | ... | ... | ... | 100 | |
| Roofs—slope under 20° | ... | 40 | 40 | 25 | 25 | 30 | 30 | 50 | 30 | 40 | 30 | 50 | 30 | 30 | 40 | 25 |
| Over 20° (hor. proj.) | ... | ... | ... | ... | ... | ... | ... | 50 | ... | ... | 30 | ... | ... | 20 | 40 | 25 |
| Wind pressures | 30 | . | 30 | 20 | 20 | ... | 30 | 30 | ... | 30 | 30 | ... | 30 | 20 | ... | 30 |

## CONTENTS OF STORAGE WAREHOUSES

| Material | Pounds per cubic foot of space | Height of pile, feet | Pounds per square foot of floor | Recommended live loads, pounds per square foot |
|---|---|---|---|---|
| **Produce, Grain, Fruit, Etc.** | | | | |
| Grain, in bulk | | | | |
| Barley and corn | 37 | 8 | 296 | 250 to 300 |
| Oats | 26 | 8 | 208 | |
| Rye and wheat | 48 | 8 | 384 | |
| Fruit and vegetables, in bulk | | | | |
| Apples, pears, etc | 38 | 8 | 304 | |
| Potatoes, turnips, etc | 44 | 8 | 352 | |
| Miscellaneous produce, packed | | | | |
| Beans, in bags | 40 | 8 | 320 | |
| Corn, in bags | 31 | 8 | 248 | |
| Cornmeal, in barrels | 37 | 6½ | 240 | |
| Oats, in bags | 26 | 9 | 234 | |
| Rice, in bags | 58 | 5 | 290 | |
| Wheat, in bags | 39 | 8 | 312 | |
| Wheat flour, in barrels | 40 | 7 | 280 | |
| Hay, in bales, not compressed | 14 | 9 | 126 | |
| Hay, in bales, compressed | 24 | 9 | 216 | |
| Straw, in bales, compressed | 19 | 9 | 171 | |
| **Groceries** | | | | |
| Miscellaneous articles, packed | | | | |
| Butter, lard, etc., in barrels | 32 | 6 | 192 | 250 to 300 |
| Canned goods, preserves, etc., in cases | 58 | 6 | 348 | |
| Cheese | 30 | 8 | 240 | |
| Coffee, green, in bags | 39 | 8 | 312 | |
| Coffee, roasted, in bags | 33 | 8 | 264 | |
| Dates and figs, in cases, average | 65 | 5 | 325 | |
| Meat, beef, pork, etc., in barrels | 37 | 5 | 185 | |
| Molasses, in barrels | 48 | 5 | 240 | |
| Salt, finely ground, in sacks | 60 | 5 | 300 | |
| Soap powder, in cases | 38 | 8 | 288 | |
| Starch, in barrels | 25 | 7 | 175 | |
| Sugar, in barrels | 43 | 5 | 215 | |
| Tea, in chests | 25 | 8 | 200 | |
| Wines, liquors, etc., in barrels | 48 | 5 | 240 | |
| **Dry Goods, Cotton, Wool, Etc.** | | | | |
| Cotton, in bales, compressed, average | 25 | 9 | 225 | 200 to 250 |
| Cotton, unbleached goods, in bales | 24 | 9 | 216 | |
| Cotton, tickings and duck, in bales | 35 | 8 | 280 | |
| Cotton, printed goods, in bales | 19 | 9 | 171 | |
| Cotton, printed goods, in cases | 31 | 8 | 248 | |
| Cotton, quilts and flannels, in cases | 16 | 9 | 144 | |
| Cotton, yarn, in cases | 25 | 8 | 200 | |
| Hemp, in bales, compressed | 22 | 8 | 176 | |
| Hemp, manila, in bales, compressed | 26 | 9 | 234 | |
| Hemp, sisal, in bales, compressed | 24 | 9 | 216 | |
| Hemp, tow, in bales, compressed | 29 | 9 | 261 | |
| Hemp, burlaps, in bales, compressed | 43 | 6 | 258 | |
| Jute, in bales, compressed | 41 | 6 | 246 | |
| Linen, bleached goods, in cases | 35 | 7 | 245 | |
| Linen, damask goods, in cases | 50 | 5 | 250 | |
| Wool, in bales, not compressed | 13 | 9 | 117 | |
| Wool, in bales, compressed | 48 | 5 | 240 | |
| Wool, dress goods, flannels, in cases | 18 | 9 | 162 | |
| Wool, worsted goods, in cases | 27 | 9 | 243 | |
| Rags, in bales, compressed | 19 | 9 | 171 | |
| Excelsior, in bales, compressed | 19 | 9 | 171 | |

## CONTENTS OF STORAGE WAREHOUSES

| Material | Pounds per cubic foot of space | Height of pile, feet | Pounds per square foot of floor | Recommended live loads, pounds per square foot |
|---|---|---|---|---|
| **Drugs, Oils, Paints, Etc.** | | | | |
| Chemicals: | | | | |
| Acids, muriatic and nitric, in carboys | 45 | 1⅔ | 75 | 200 to 250 |
| Acids, sulphuric, in carboys | 60 | 1⅔ | 100 | |
| Ammonia, in carboys | 30 | 1⅔ | 50 | |
| Alum, pearl alum, in barrels | 33 | 7 | 231 | |
| Bleaching powder, in hogsheads | 31 | 3⅓ | 103 | |
| Copper sulphate, blue vitriol, in bbls. | 45 | 5 | 225 | |
| Soda, caustic soda, in iron drums | 88 | 3⅓ | 294 | |
| Soda, soda ash, in hogsheads | 62 | 2¾ | 170 | |
| Soda crystals, sal soda, in barrels | 30 | 5 | 150 | |
| Soda nitrate, niter, in barrels | 45 | 5 | 225 | |
| Soda silicate, in barrels | 53 | 5 | 265 | |
| Zinc sulphate, white vitriol, in barrels | 40 | 5 | 200 | |
| Oils, fats, resins, etc.: | | | | |
| Glycerine, in cases | 52 | 6 | 312 | |
| Oils, animal, lard, etc., in barrels | 34 | 6 | 204 | |
| Oils, vegetable, linseed, in barrels | 36 | 6 | 216 | |
| Oils, mineral, lubricants, in barrels | 35 | 6 | 210 | |
| Oils, petroleum, kerosene, in barrels | 33 | 6 | 198 | |
| Oils, naphtha, gasolene, in barrels | 28 | 6 | 168 | |
| Rosin, in barrels | 48 | 6 | 288 | |
| Shellac gum, in boxes | 38 | 6 | 228 | |
| Tallow, in barrels | 37 | 6 | 222 | |
| Dye stuffs, paints, etc.: | | | | |
| Indigo, in boxes | 43 | 6 | 258 | |
| Logwood extract, in boxes | 70 | 4½ | 315 | |
| Sumac, in boxes | 39 | 5 | 195 | |
| Red lead, litharge, dry, in barrels | 132 | 3¾ | 495 | |
| White lead, dry, in barrels | 86 | 4¾ | 409 | |
| White lead, paste, in cans | 174 | 3½ | 609 | |
| **Building Materials** | | | | |
| Cement, natural, in barrels | 59 | 6 | 354 | 300 to 400 |
| Cement, Portland, in barrels | 73 | 6 | 438 | |
| Lime, quick lime, ground, in barrels | 50 | 5 | 250 | |
| Plaster of Paris, ground, in barrels | 53 | 5 | 265 | |
| **Sheet Metal and Wire** | | | | |
| Sheet tin, in boxes | 278 | 1½ | 417 | 300 to 400 |
| Wire, insulated copper, in coils | 63 | 5 | 315 | |
| Wire, galvanized iron, in coils | 74 | 4½ | 333 | |
| Wire, magnet wire, on spools | 75 | 6 | 450 | |
| **Miscellaneous** | | | | |
| Chinaware, glassware, in crates | 40 | 8 | 320 | 300 to 400 |
| Chinaware, glassware, in casks | 14 | 9 | 126 | |
| Glass, in boxes | 60 | 6 | 360 | |
| Hardware, door and sash checks, in cases | 46 | 6 | 276 | |
| Hardware, hinges, in cases | 64 | 6 | 384 | |
| Hardware, locks, in cases | 31 | 6 | 186 | |
| Hardware, screws, in boxes | 101 | 4 | 404 | |
| Hides, raw, not compressed, in bales | 13 | 10 | 130 | |
| Hides, raw, compressed, in bales | 23 | 10 | 230 | |
| Leather, in bales | 16 | 10 | 160 | |
| Paper, calendered paper | 50 | 6 | 300 | |
| Paper, newspaper, manila, strawboards | 35 | 6 | 210 | |
| Paper, writing paper | 64 | 6 | 384 | |
| Rope in coils | 42 | 6 | 252 | |

TABLE 54

## WEIGHTS OF BUILDING MATERIALS

| Kind | Weight in lb. per sq. ft. |
|---|---|
| FLOORS | |
| ⅞-in. maple finish floor and ⅞-in. spruce under floor on 2 × 4-in. sleepers, 16-in. centers, with 2-in. dry cinder concrete filling | 18 |
| Cinder concrete filling per inch of thickness | 7 |
| Cement finish per inch of thickness | 12 |
| Asphalt mastic flooring 1½ in. thick | 18 |
| 3-in. creosoted wood blocks on ½-in. mortar base | 21 |
| Solid flat tile on 1-in. mortar bed | 23 |
| CEILINGS | |
| Plaster on tile or concrete | 5 |
| Suspended metal lath and plaster | 10 |
| ROOFS | |
| Five-ply felt and gravel | 6 |
| Four-ply felt and gravel | 5½ |
| Three-ply ready roofing | 1 |
| Cement tile | 16 |
| Slate, ¼ in. thick | 9½ |
| Sheathing, 1 in. thick, yellow pine | 4 |
| 2-in. book tile | 12 |
| 3-in. book tile | 20 |
| Skylight with galvanized iron frame, ⅜-in. glass | 6 |

| Kind | Weight in lb. per sq. ft. | | |
|---|---|---|---|
| | Unplastered | One side plastered | Both sides plastered |
| WALLS | | | |
| 9-in. brick wall | 84 | 89 | |
| 13-in. brick wall | 121 | 126 | |
| 18-in. brick wall | 168 | 173 | |
| 22-in. brick wall | 205 | 210 | |
| 26-in. brick wall | 243 | 248 | |
| 4-in. brick, 4-in. tile backing | 60 | 65 | |
| 4-in. brick, 8-in. tile backing | 75 | 80 | |
| 9-in. brick, 4-in. tile backing | 102 | 107 | |
| 8-in. tile | 33 | 38 | 43 |
| 12-in. tile | 45 | 50 | 55 |
| PARTITIONS | | | |
| 3-in. clay tile | 17 | 22 | 27 |
| 4-in. clay tile | 18 | 23 | 28 |
| 6-in. clay tile | 25 | 30 | 35 |
| 8-in. clay tile | 31 | 36 | 41 |
| 10-in. clay tile | 35 | 40 | 45 |
| 3-in. gypsum block | 10 | 15 | 20 |
| 4-in. gypsum block | 12 | 17 | 22 |
| 5-in. gypsum block | 14 | 19 | 24 |
| 6-in. gypsum block | 16 | 21 | 26 |
| 2-in. solid plaster | ... | ... | 20 |
| 4-in. solid plaster | ... | ... | 32 |
| 4-in. hollow plaster | ... | ... | 22 |

| Kind | Weight in lb. per cu. ft. | Kind | Weight in lb. per cu. ft. |
|---|---|---|---|
| Beech | 42 | Limestone | 150 |
| Birch | 42 | Maple | 42 |
| Brickwork | 120 | Marble | 168 |
| Concrete, cinder, structural | 108 | Oak | 48 |
| Concrete, cinder, floor filling | 96 | Pine, southern yellow | 42 |
| Concrete, stone | 144 | Sandstone | 144 |
| Concrete, stone, reinforced | 150 | Spruce | 30 |
| Douglas fir | 36 | Terra cotta, architectural, voids unfilled | 72 |
| Granite | 168 | Terra cotta, architectural, voids filled | 120 |
| Granolithic surface | 144 | | |

# APPENDIX

## RULINGS PERTAINING TO DESIGN AND WORKING STRESSES

### Joint Committee Recommendations*

### Design

**Massive Concrete.**—In the design of massive or plain concrete, no account should be taken of the tensile strength of the material, and sections should usually be proportioned so as to avoid tensile stresses except in slight amounts to resist indirect stresses. This will generally be accomplished in the case of rectangular shapes if the line of pressure is kept within the middle third of the section, but in very large structures, such as high masonry dams, a more exact analysis may be required. Structures of massive concrete are able to resist unbalanced lateral forces by reason of their weight; hence the element of weight rather than strength often determines the design. A leaner and relatively cheap concrete, therefore, will often be suitable for massive concrete structures.

It is desirable generally to provide joints at intervals to localize the effect of contraction.

Massive concrete is suitable for dams, retaining walls, and piers in which the ratio of length to least width is relatively small. Under ordinary conditions this ratio should not exceed four. It is also suitable for arches of moderate span.

**Reinforced Concrete.**—The use of metal reinforcement is particularly advantageous in members such as beams in which both tension and compression exist, and in columns where the principal stresses are compressive and where there also may be cross-bending. Therefore, the theory of design here presented relates mainly to the analysis of beams and columns.

**General Assumptions.** (*a*) *Loads.*—The forces to be resisted are those due to:

1. *The dead load*, which includes the weight of the structure and fixed loads and forces.

2. *The live load*, or the loads and forces which are variable. The dynamic effect of the live load will often require consideration. Allowance for the lattter is preferably made by a proportionate increase in either the live load or the live load stresses. The working stresses hereinafter recommended are intended to apply to the equivalent static stresses thus determined.

In the case of high buildings the live load on columns may be reduced in accordance with the usual practice.

(*b*) *Lengths of Beams and Columns.*—The span length for beams and slabs simply supported should be taken as the distance from center to center of supports, but need not be taken to exceed the clear span plus the depth of beam or slab. For continuous or restrained beams built monolithically into supports the span length may be taken as the clear distance between faces of supports. Brackets should not be considered as reducing the clear span in the sense here intended, except that when brackets which make an angle of 45 degrees or more with the axis of a restrained beam are built monolithically with the beam, the span may be measured from the section where the combined depth of beam and bracket is at least one-third more than the depth of the beam. Maximum negative moments are to be considered as existing at the end of the span as here defined.

When the depth of a restrained beam is greater at its ends than at midspan and the slope of the bottom of the beam at its ends makes an angle of not more than 15 degress with the direction of the axis of the beam at midspan, the span length may be measured from face to face of supports.

The length of columns should be taken as the maximum unstayed length.

(*c*) *Stresses.*—The following assumptions are recommended as a basis for calculations:

1.—Calculations will be made with reference to working stresses and safe loads rather than with reference to ultimate strength and ultimate loads.

2.—A plane section before bending remains plane after bending.

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* From Final Report of the Special Committee on Concrete and Reinforced Concrete of the American Society of Civil Engineers, presented before the Society, Jan. 17, 1917.

3.—The modulus of elasticity of concrete in compression is constant within the usual limits of working stresses. The distribution of compressive stress in beams is, therefore, rectilinear.

4.—In calculating the moment of resistance of beams the tensile stresses in the concrete are neglected.

5.—The adhesion between the concrete and the reinforcement is perfect. Under compressive stress the two materials are, therefore, stressed in proportion to their moduli of elasticity.

6.—The ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete is taken at 15, except as modified in section on "Working Stresses."

7.—Initial stress in the reinforcement due to contraction or expansion of the concrete is neglected.

It is recognized that some of the assumptions given herein are not entirely borne out by experimental data. They are given in the interest of simplicity and uniformity, and variations from exact conditions are taken into account in the selection of formulas and working stresses.

The deflection of a beam depends upon the strength and stiffness developed throughout its length. For calculating deflection a value of 8 for the ratio of the moduli will give results corresponding approximately with the actual conditions.

**T-Beams.**—In beam and slab construction an effective bond should be provided at the junction of the beam and slab. When the principal slab reinforcement is parallel to the beam, transverse reinforcement should be used extending over the beam and well into the slab.

The slab may be considered an integral part of the beam, when adequate bond and shearing resistance between slab and web of beam is provided, but its effective width shall be determined by the following rules:

(*a*)—It shall not exceed one-fourth of the span length of the beam.

(*b*)—Its overhanging width on either side of the web shall not exceed six times the thickness of the slab.

In the design of continuous T-beams, due consideration should be given to the compressive stress at the support.

Beams in which the T-form is used only for the purpose of providing additional compression area of concrete should preferably have a width of flange not more than three times the width of the stem and a thickness of flange not less than one-third of the depth of the beam. Both in this form and in the beam and slab form the web stresses and the limitations in placing and spacing the longitudinal reinforcement will probably be controlling factors in design.

**Floor Slabs Supported Along Four Sides.**—Floor slabs having the supports extending along the four sides should be designed and reinforced as continuous over the supports. If the length of the slab exceeds 1.5 times its width the entire load should be carried by transverse reinforcement.

For uniformly distributed loads on square slabs, one-half the live and dead load may be used in the calculations of moment to be resisted in each direction. For oblong slabs, the length of which is not greater than one and one-half times their width, the moment to be resisted by the transverse reinforcement may be found by using a proportion of the live and dead load equal to that given by the formula $r = \frac{l}{b} - 0.5$, where $l$ = length and $b$ = breadth of slab. The longitudinal reinforcement should then be proportioned to carry the remainder of the load.

In placing reinforcement in such slabs account may well be taken of the fact that the bending moment is greater near the center of the slab than near the edges. For this purpose two-thirds of the previously calculated moments may be assumed as carried by the center half of the slab and one-third by the outside quarters.

Loads carried to beams by slabs which are reinforced in two directions will not be uniformly distributed to the supporting beams and the distribution will depend on the relative stiffness of the slab and the supporting beams. The distribution which may be expected ordinarily is a variation of the load in the beam in accordance with the ordinates of a parabola, having its vertex at the middle of the span. For any given design, the probable distribution shlould be ascertained and the moments in the beam calculated accordingly.

**Continuous Beams and Slabs.**—When the beam or slab is continuous over its supports, reinforcement should be fully provided at points of negative moment; and the stresses in concrete recommended in the section on "Working Stresses" should not be exceeded. In computing the positive and negative moments in beams and slabs continuous over several supports, due to uniformly distributed loads, the following rules are recommended:

(*a*) For floor slabs the bending moments at center and at support should be taken at $\frac{wl^2}{12}$ for both dead and live loads, where $w$ represents the load per linear unit and $l$ the span length.

(*b*) For beams the bending moment at center and at support for interior spans should be taken at $\frac{wl^2}{12}$, and for end spans it should be taken at $\frac{wl^2}{10}$ for center and interior support, for both dead and live loads.

(*c*) In the case of beams and slabs continuous for two spans only, with their ends restrained, the bending moment both at the central support and near the middle of the span should be taken at $\frac{wl^2}{10}$.

(*d*) At the ends of continuous beams the amount of negative moment which will be developed in the beam will depend on the condition of restraint or fixedness, and this will depend on the form of construction used. In the ordinary cases a moment of $\frac{wl^2}{16}$ may be taken; for small beams running into heavy columns this should be increased, but not to exceed $\frac{wl^2}{12}$.

For spans of unusual length, or for spans of materially unequal length, more exact calculations should be made. Special consideration is also required in the case of concentrated loads.

Even if the center of the span is designed for a greater bending moment than is called for by (*a*) or (*b*), the negative moment at the support should not be taken as less than the values there given.

Where beams are reinforced on the compression side, the steel may be assumed to carry its proportion of stress in accordance with the ratio of moduli of elasticity, as given in the section on "Working Stresses." Reinforcing bars for compression in beams should be straight and should be two diameters in the clear from the surface of the concrete. For the positive bending moment, such reinforcement should not exceed one per cent of the area of the concrete. In the case of cantilever and continuous beams, tensile and compressive reinforcement over supports should extend sufficiently beyond the support and beyond the point of inflection to develop the requisite bond strength.

In construction made continuous over supports it is important that ample foundations should be provided; for unequal settlements are liable to produce unsightly, if not dangerous cracks. This effect is more likely to occur in low structures.

Girders, such as wall girders, which have beams framed into one side only, should be designed to resist torsional moment arising from the negative moment at the end of the beam.

**Bond Strength and Spacing of Reinforcement.**—Adequate bond strength should be provided. The formula hereinafter given for bond stresses in beams is for straight longitudinal bars. In beams in which a portion of the reinforcement is bent up near the end, the bond stress at places, in both the straight bars and the bent bars, will be considerably greater than for all the bars straight, and the stress at some point may be several times as much as that found by considering the stress to be uniformly distributed along the bar. In restrained and cantilever beams full tensile stress exists in the reinforcing bars at the point of support and the bars should be anchored in the support sufficiently to develop this stress.

In case of anchorage of bars, an additional length of bar should be provided beyond that found on the assumption of uniform bond stress, for the reason that before the bond resistance at the end of the bar can be developed the bar may have begun to slip at another point and "running" resistance is less than the resistance before slip begins.

Where high bond resistance is required, the deformed bar is a suitable means of supplying the necessary strength. But it should be recognized that even with a deformed bar initial slip occurs at early loads, and that the ultimate loads obtained in the usual tests for bond resistance may be misleading. Adequate bond strength throughout the length of a bar is preferable to end anchorage, but, as an additional safeguard, such anchorage may properly be used in special cases. Anchorage furnished by short bends at a right angle is less effective than by hooks consisting of turns through 180 degrees.

The lateral spacing of parallel bars should be not less than three diameters from center to center, nor should the distance from the side of the beam to the center of the nearest bar be less than two diameters. The clear spacing between two layers of bars should be not less than one inch. The use of more than two layers is not recommended, unless the layers are tied together by adequate metal connections, particularly at and near points where bars are bent up or bent down. Where more than one layer is used, at least all bars above the lower layer should be bent up and anchored beyond the edge of the support.

**Diagonal Tension and Shear.**—When a reinforced concrete beam is subjected to flexural action, diagonal tensile stresses are set up. A beam without web reinforcement will fail if these stresses exceed the tensile strength of the concrete. When web reinforcement, made up of stirrups or of diagonal bars secured to the longitudinal reinforcement, or of longitudinal reinforcing bars bent up at several points, is used, new conditions prevail, but even in this case at the beginning of loading the diagonal tension developed is taken principally by the concrete, the deformations which are developed in the concrete permitting but little stress to be taken by the web reinforcement. When the resistance of the concrete to the diagonal tension is overcome at any point in the depth of the beam, greater stress is at once set up in the web reinforcement.

For homogeneous beams the analytical treatment of diagonal tension is not very complex, the diagonal tensile stress is a function of the horizontal and vertical shearing stresses and of the horizontal tensile stress at the point considered, an as the intensity of these three stresses varies from the neutral axis to the remotest fibre, the intensity of the diagonal tension will be different at different points in the section, and will change with different proportionate dimensions of length to depth of beam. For the composite structure of reinforced concrete beams, an analysis of the web stresses, and particularly of the diagonal tensile stresses, is very complex; and when the variations due to a change from no horizontal tensile stress in the concrete at remotest fibre to the presence of horizontal tensile stress at some point below the neutral axis are considered, the problem becomes more complex and indefinite. Under these circumstances, in designing recourse is had to the use of the calculated vertical shearing stress as a means of comparing or measuring the diagonal tensile stresses developed, it being understood that the vertical shearing stress is not the numerical equivalent of the diagonal tensile stress, and that there is not even a constant ratio between them. It is here recommended that the maximum vertical shearing stress in a section be used as the means of comparison of the resistance to diagonal tensile stress developed in the concrete in beams not having web reinforcement.

Even after the concrete has reached its limit of resistance to diagonal tension, if the beam has web reinforcement, conditions of beam action will continue to prevail, at least through the compression area, and the web reinforcement will be called on to resist only a part of the web stresses. From experiments with beams it is concluded that it is safe practice to use only two-thirds of the external vertical shear in making calculations of the stresses that come on stirrups, diagonal web pieces, and bent-up bars, and it is here recommended for calculations in designing that two-thirds of the external vertical shear be taken as producing stresses in web reinforcement.

It is well established that vertical members attached to or looped about horizontal members, inclined members secured to horizontal members in such a way as to insure against slip, and the bending of a part of the longitudinal reinforcement at an angle, will increase the strength of a beam against failure by diagonal tension, and that a well-designed and well-distributed web reinforcement may under the best conditions increase the total vertical shear carried to a value as much as three times that obtained when the bars are all horizontal and no web reinforcement is used.

When web reinforcement comes into action as the principal tension web resistance, the bond stresses between the longitudinal bars and the concrete are not distributed as uniformly along the bars as they otherwise would be, but tend to be concentrated at and near stirrups, and at and near the points where bars are bent up. When stirrups are not rigidly attached to the longitudinal bars, and the proportioning of bars and stirrups spacing is such that local slip of bars occurs at stirrups, the effectiveness of the stirrups is impaired, though the presence of stirrups still gives an element of toughness against diagonal tension failure.

Sufficient bond resistance between the concrete and the stirrups or diagonals must be provided in the compressing area of the beam.

The longitudinal spacing of vertical stirrups should not exceed one-half the depth of beam, and that of inclined members should not exceed three-fourths of the depth of beam.

Bending of longitudinal reinforcing bars at an angle across the web of the beam may be considered as adding to diagonal tension resistance for a horizontal distance from the point of bending equal to three-fourths of the depth of beam. Where the bending is made at two or more points, the distance between points of bending should not exceed three-fourths of the depth of the beam. In the case of a restrained beam the effect of bending up a bar at the bottom of the beam in resisting diagonal tension may not be taken as extending beyond a section at the point of inflection, and the effect of bending down a bar in the region of negative moment may be taken as extending from the point of bending down of bar nearest the support to a section not more than three-fourths of the depth of beam beyond the point of bending down of bar farthest from the support but not beyond the point of inflection. In case stirrups are used in the beam away from the region in which the bent bars are considered effective, a stirrup should be placed not farther than a distance equal to one-fourth the depth of beam from the limiting sections defined above. In case the web resistance required through the region of bent bars is greater than that furnished by the bent bars, sufficient additional web reinforcement in the form of stirrups or attached diagonals should be provided. The higher resistance to diagonal tension stresses given by unit frames having the stirrups and bent-up bars securely connected together both longitudinally and laterally is worthy of recognition. It is necessary that a limit be placed on the amount of shear which may be allowed in a beam; for when web reinforcement sufficiently efficient to give very high web resistance is used, at the higher stresses the concrete in the beam becomes checked and cracked in such a way as to endanger its durability as well as its strength.

The section to be taken as the critical section in the calculation of shearing stresses will generally be the one having the maximum vertical shear, though experiments show that the section at which diagonal tension failures occur is not just at a support even though the shear at the latter point be much greater.

In the case of restrained beams, the first stirrup or the point of bending down of bar should be placed not farther than one-half of the depth of beam away from the face of the support.

It is important that adequate bond strength or anchorage be provided to develop fully the assumed strength of all web reinforcement.

Low bond stresses in the longitudinal bars are helpful in giving resistance against diagonal tension failures and anchorage of longitudinal bars at the ends of the beams or in the supports is advantageous.

It should be noted that it is on the tension side of a beam that diagonal tension develops in a critical way, and that proper connection should always be made between stirrups or other web reinforcement and the longitudinal tension reinforcement, whether the latter is on the lower side of the beam or on its upper side. Where negative moment exists, as is the case near the supports in a continuous beam, web reinforcement to be effective must be looped over or wrapped around or be connected with the longitudinal tension reinforcing bars at the top of the beam in the same way as is necessary at the bottom of the beam at sections where the bending moment is positive.

Inasmuch as the smaller the longitudinal deformations in the horizontal reinforcement are, the less the tendency for the formation of diagonal cracks, a beam will be strengthened against diagonal tension failure by so arranging and proportioning the horizontal reinforcement that the unit stresses at points of large shear shall be relatively low.

It does not seem feasible to make a complete analysis of the action of web reinforcement, and more or less empirical methods of calculation are therefore employed. Limiting values of working stresses for different types of web reinforcement are given in the section on "Working Stresses." The conditions apply to cases commonly met in design. It is assumed that adequate bond resistance or anchorage of all web reinforcement will be provided.

When a flat slab rests on a column, or a column bears on a footing, the vertical shearing stresses in the slab or footing immediately adjacent to the column are termed punching shearing stresses. The element of diagonal tension, being a function of the bending moment as well as of shear, may be small in such cases, or may be otherwise provided for. For this reason the permissible limit of stress for punching shear may be higher than the allowable limit when the shearing stress is used as a means of comparing diagonal tensile stress. The working values recommended are given in the section on "Working Stresses."

**Columns.**—By columns are meant compression members of which the ratio of unsupported length to least width exceeds about four, and which are provided with reinforcement of one of the forms hereafter described.

It is recommended that the ratio of unsupported length of column to its least width be limited to fifteen.

The effective area of hooped columns or columns reinforced with structural shapes shall be taken as the area within the circle enclosing the spiral or the polygon enclosing the structural shapes.

Columns may be reinforced by longitudinal bars; by bands, hoops, or spirals, together with longitudinal bars; or by structural forms which are sufficiently rigid to have value in themselves as columns. The general effect of closely spaced hooping is to greatly increase the toughness of the column and to add to its ultimate strength, but hooping has little effect on its behavior within the limit of elasticity. It thus renders the concrete a safer and more reliable material, and should permit the use of a somewhat higher working stress. The beneficial effects of toughening are adequately provided by a moderate amount of hooping, a larger amount serving mainly to increase the ultimate strength and the deformation possible before ultimate failure.

Composite columns of structural steel and concrete in which the steel forms a column by itself should be designed with caution. To classify this type as a concrete column reinforced with structural steel is hardly permissible, as the steel, generally, will take the greater part of the load. When this type of column is used, the concrete should be adequately tied together by tie plates or lattice bars, which, together with other details, such as splices, etc., should be designed in conformity with standard practice for structural steel. The concrete may exert a beneficial effect in restraining the steel from lateral deflection and also in increasing the carrying capacity of the column. The proportion of load to be carried by the concrete will depend on the form of the column and the method of construction. Generally, for high percentages of steel, the concrete will develop relatively low unit stresses, and caution should be used in placing dependence on the concrete.

The following recommendations are made for the relative working stresses in the concrete for the several types of columns:

(*a*) Columns with longitudinal reinforcement to the extent of not less than 1 per cent and not more than 4 per cent, and with lateral ties of not less than ¼ inch in diameter 12 inches apart, nor more than 16 diameters of the longitudinal bar: the unit stress recommended for axial compression, on concrete piers having a length not more than four diameters, in section on "Working Stresses."

(*b*) Columns reinforced with not less than 1 per cent and not more than 4 per cent of longitudinal bars and with circular hoops or spirals not less than 1 per cent of the volume of the concrete and as hereinafter specified: a unit stress 55 per cent higher than given for (*a*), provided the ratio of unsupported length of column to diameter of the hooped core is not more than 10.

The foregoing recommendations are based on the following conditions:

It is recommended that the minimum size of columns to which the working stresses may be applied be 12 inches out to out.

In all cases longitudinal reinforcement is assumed to carry its proportion of stress in accordance with (*c*) *Stresses*, page 243. The hoops or bands are not to be counted on directly as adding to the strength of the column.

Longitudinal reinforcement bars should be maintained straight, and should have sufficient lateral support to be securely held in place until the concrete has set.

Where hooping is used, the total amount of such reinforcement shall be not less than 1 per cent of the volume of the column, enclosed. The clear spacing of such hooping shall not be greater than one-sixth the diameter of the enclosed column and preferably not greater than one-tenth, and in no case more than 2½ in. Hooping is to be circular and the ends of bands must be united in such a way as to develop their full strength. Adequate means must be provided to hold bands or hoops in place so as to form a column, the core of which shall be straight and well centered. The strength of hooped columns depends very much upon the ratio of length to diameter of hooped core, and the strength due to hooping decreases rapidly as this ratio increases beyond five. The working stresses recommended are for hooped columns with a length of not more than ten diameters of the hooped core.

The Committee has no recommendation to make for a formula for working stresses for columns longer than ten diameters.

Bending stresses due to eccentric loads, such as unequal spans of beams, and to lateral forces, must be provided for by increasing the section until the maximum stress does not exceed the values above specified. Where tension is possible in the longitudinal bars of the columns, adequate connection between the ends of the bars must be provided to take this tension.

**Reinforcing for Shrinkage and Temperature Stresses.**—When areas of concrete too large to expand and contract freely as a whole are exposed to atmospheric conditions, the changes of form due to shrinkage and to action of temperature are such that cracks may occur in the mass unless precautions are taken to distribute the stresses so as to prevent the cracks altogether or to render them very small. The distance apart of the cracks, and consequently their size, will be directly proportional to the diameter of the reinforcement and to the tensile strength of the concrete, and inversely proportional to the percentage of reinforcement and also to its bond resistance per unit of surface area. To be most effective, therefore, reinforcement (in amount generally not less than one-third of 1 per cent of the gross area) of a form which will develop a high bond resistance should be placed near the exposed surface and be well distributed. Where openings occur the area of cross-section of the reinforcement should not be reduced. The allowable size and spacing of cracks depends on various considerations, such as the necessity for water-tightness, the importance of appearance of the surface, and the atmospheric changes.

The tendency of concrete to shrink makes it necessary, except where expansion is provided for, to thoroughly connect the component parts of the frame of articulated structures, such as floor and wall members in buildings, by the use of suitable reinforcing material. The amount of reinforcement for such connection should bear some relation to the size of the members connected, larger and heavier members requiring stronger connections. The reinforcing bars should be extended beyond the critical section far enough, or should be sufficiently anchored to develop their full tensile strength.

**Flat Slab.**—The continuous flat slab reinforced in two or more directions and built monolithically with the supporting columns (without beams or girders) is a type of construction which is now extensively used and which has recognized advantages for certain types of structures as, for example, warehouses in which large, open floor space is desired. In its construction, there is excellent opportunity for inspecting the position of the reinforcement. The conditions attending deposition and placing of concrete are favorable to securing uniformity and soundness in the concrete. The recommendations in the following paragraphs relate to flat slabs extending over several rows of panels in each direction. Necessarily the treatment is more or less empirical.

The co-efficients and moments given relate to uniformly distributed loads.

(*a*) *Column Capital.*—It is usual in flat slab construction to enlarge the supporting columns at their top, thus forming column capitals. The size and shape of the column capital affect the strength of the structure in several ways. The moment of the external forces which the slab is called upon to resist is dependent upon the size of the capital; the section of the slab immediately above the upper periphery of the capital carries the highest amount of punching shear; and the bending moment developed in the column by an eccentric or unbalanced loading of the slab is greatest at the under surface of the slab. Generally the horizontal section of the column capital should be round or square with rounded corners. In oblong panels the section may be oval or oblong, with dimensions proportional to the panel dimensions. For computation purposes, the diameter of the column capital will be considered to be measured where its vertical thickness is at least 1½ inches, provided the slope of the capital below this point nowhere makes an angle with the vertical of more than 45 degrees. In case a cap is placed above the column capital, the part of this cap within a cone made by extending the lines of the column capital upward at the slope of 45 degrees to the bottom of the slab or dropped panel may be considered as part of the column capital in determining the diameter for design purposes. Without attempting to limit the size of the column capital for special cases, it is recommended that the diameter of the column capital (or its dimensions parallel to the edge of the panel) generally be made not less than one-fifth of the dimension of the panel from center to center of adjacent columns. A diameter equal to 0.225 of the panel length has been used quite widely and acceptably. For heavy loads or large panels especial attention should be given to designing and reinforcing the column capital with respect to compressive stresses and bending moments. In the case of heavy loads or large panels, and where the conditions of the panel loading or variations in panel length or other conditions cause high bending stresses in the column, and also for column capitals smaller than the size herein recommended, especial attention should be given to designing and reinforcing the column capital with respect to compression and to rigidity of connection to floor slab.

(*b*) *Dropped Panel.*—In one type of construction the slab is thickened throughout an area surrounding the column capital. The square or oblong of thickened slab thus formed is called a dropped panel or a drop. The thickness and the width of the dropped panel may be governed by the amount of resisting moment to be provided (the compressive stress in the concrete being dependent upon both thickness and width), or its thickness may be governed by the resistance to shear required at the edge of the column capital and its width by the allowable compressive stresses and shearing stresses in the thinner portion of the slab adjacent to the dropped panel. Generally, however, it is recommended that the width of the dropped panel be at least four-tenths of the corresponding side of the panel as measured from center to center of columns, and that the offset in thickness be not more than five-tenths of the thickness of the slab outside the dropped panel.

(*c*) *Slab Thickness.*—In the design of a slab, the resistance to bending and to shearing forces will largely govern the thickness, and, in the case of large panels with light loads, resistance to deflection may be a controlling factor. The following formulas for minimum thicknesses are recommended as general rules of design when the diameter of the column capital is not less than one-fifth of the dimension of the panel from center to center of adjacent columns, the large dimension being used in the case of oblong panels. For notation, let

$t$ = total thickness of slab in inches.
$L$ = panel length in feet.
$w$ = sum of live load and dead load in pounds per square foot.

Then, for a slab without dropped panels, minimum $t = 0.024L\sqrt{w} + 1\frac{1}{2}$; for a slab with dropped panels, minimum $t = 0.02L\sqrt{w} + 1$; for a dropped panel whose width is four-tenths of the panel length, minimum $t = 0.03L\sqrt{w} + 1\frac{1}{2}$.

In no case should the slab thickness be made less than six inches, nor should the thickness of a floor slab be made less than one-thirty-second of the panel length, nor the thickness of a roof slab less than one-fortieth of the panel length.

(*d*) *Bending and Resisting Moments in Slabs.*—If a vertical section of a slab be taken across a panel along a line midway between columns, and if another section be taken along an edge of the panel parallel to the first section, but skirting the part of the periphery of the column capitals at the two corners of the panels, the moment of the couple formed by the external load on the half panel, exclusive of that over the column capital (sum of dead and live load) and the resultant of the external shear or reaction at the support at the two column capitals (see Fig. 1), may be found by ordinary static analysis. It will be noted that the edges of the area here considered are along lines of zero shear except around the column capitals. This moment of the external forces acting on the half panel will be resisted by the numerical sum of (*a*) the moment of the internal stresses at the section of the panel midway between columns (positive resisting moment) and (*b*) the moment of the internal stresses at the section referred to at the end of the panel (negative resisting moment). In the curved portion of the end section (that skirting the column), the stresses considered are the components which act parallel to the normal stresses on the straight portion of the section. Analysis shows that, for a uniformly distributed load, and round columns, and square panels, the numerical sum of the positive moment and the negative moment at the two sections named is given quite closely by the equation

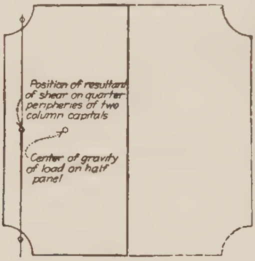
Position of resultant of shear on quarter peripheries of two column capitals
Center of gravity of load on half panel

FIG. 1.

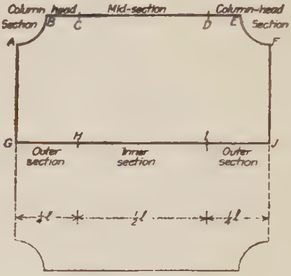

FIG. 2.

$$M_x = \frac{1}{8} wl \left( l - \frac{2c}{3} \right)^2$$

In this formula and in those which follow relating to oblong panels:

$w$ = sum of the live and dead load per unit of area.
$l$ = side of a square panel measured from center to center of columns.
$l_1$ = one side of the oblong panel measured from center to center of columns.
$l_2$ = other side of oblong panel measured in the same way.
$c$ = diameter of the column capital.
$M_x$ = numerical sum of positive moment and negative moment in one direction.
$M_y$ = numerical sum of positive moment and negative moment in the other direction.

(See paper and closure, Statical Limitations upon the Steel Requirement in Reinforced Concrete Flat Slab Floors, by John R. Nichols, Jun. Am. Soc. C. E., *Transactions* Am. Soc. C. E. Vol. LXXVII.)

For oblong panels, the equations for the numerical sums of the positive moment and the negative moment at the two sections named become

$$M_x = \frac{1}{8} wl_2 \left( l_1 - \frac{2c}{3} \right)^2$$

$$M_y = \frac{1}{8} wl_1 \left( l_2 - \frac{2c}{3} \right)^2$$

Where $M_x$ = is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimensions $l_2$, and $M_y$ is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimensions $l_1$.

What proportion of the total resistance exists as positive moment and what as negative moment is not readily determined. The amount of the positive moment and that of the negative moment may be expected to vary somewhat with the design of the slab. It seems proper, however, to make the division of total resisting moment in the ratio of three-eighths for the positive moment to five-eighths for the negative moment.

With reference to variations in stress along the sections, it is evident from conditions of flexure that the resisting moment is not distributed uniformly along either the section of positive moment or that of negative moment. As the law of the distribution is not known definitely, it will be necessary to make an empirical apportionment along the sections; and it will be considered sufficiently accurate generally to divide the sections into two parts and to use an average value over each part of the panel section.

The relatively large breadth of structure in a flat slab makes the effect of local variations in the concrete less than would be the case for narrow members like beams. The tensile resistance of the concrete is less affected by cracks. Measurements of deformations in buildings under heavy load indicate the presence of considerable tensile resistance in the concrete, and the presence of this tensile resistance acts to decrease the intensity of the compressive stresses. It is believed that the use of moment coefficients somewhat less than those given in a preceding paragraph as derived by analysis is warranted, the calculations of resisting moment and stresses in concrete and reinforcement being made according to the assumptions specified in this report and no change being made in the values of the working stresses ordinarily used. Accordingly, the values of the moments which are recommended for use are somewhat less than those derived by analysis. The values given may be used when the column capitals are round, oval, square or oblong.

(*e*) *Names for Moment Sections.*—For convenience, that portion of the section across a panel along a line midway between columns which lies within the middle two quarters of the width of the panel (*HI*. Fig. 2), will be called the inner section, and that portion in the two outer quarters of the width of the panel (*GH* and *IJ*, Fig. 2) will be called the outer sections. Of the section which follows a panel edge from column capital to column capital and which includes the quarter peripheries of the edges of two column capitals, that portion within the middle two quarters of the panel width (*CD*, Fig. 2) will be called the mid-section, and the two remaining portions (*ABC* and *DEF*, Fig. 2), each having a projected width equal to one-fourth of the panel width, will be called the column-head sections.

(*f*) *Positive Moment.*—For a square interior panel, it is recommended that the positive moment for a section in the middle of a panel extending across its width be taken as $\frac{1}{25}wl\left(l - \frac{2c}{3}\right)^2$. Of this moment, at least 25 per cent should be provided for in the inner section; in the two outer sections of the panel at least 55 per cent of the specified moment should be provided for in slabs not having dropped panels, and at least 60 per cent in slabs having dropped panels, except that in calculations to determine necessary thickness of slab away from the dropped panel at least 70 per cent of the positive moment should be considered as acting in the two outer sections.

(*g*) *Negative Moment.*—For a square interior panel, it is recommended that the negative moment for a section which follows a panel edge from column capital to column capital and which includes the quarter peripheries of the edges of the two column capitals (the section altogether forming the projected width of the panel) be taken as $\frac{1}{15}wl\left(l - \frac{2c}{3}\right)^2$. Of this negative moment, at least 20 per cent should be provided for in the mid-section and at least 65 per cent in the two column-head sections of the panel, except that in slabs having dropped panels at least 80 per cent of the specified negative moment should be provided for in the two column-head sections of the panel.

(*h*) *Moments for Oblong Panels.*—When the length of a panel does not exceed the breadth by more than 5 per cent, computation may be made on the basis of a square panel with sides equal to the mean of the length and the breadth.

When the long side of an interior oblong panel exceeds the short side by more than one-twentieth and by not more than one-third of the short side, it is recommended that the positive moment be taken as $\frac{1}{25}wl_2\left(l_1 - \frac{2c}{3}\right)^2$ on a section parallel to the dimension $l_2$, and $\frac{1}{25}wl_1\left(l_2 - \frac{2c}{3}\right)^2$ on a section parallel to dimension $l_1$; and that the negative moment be taken as $\frac{1}{15}wl_2\left(l_1 - \frac{2c}{3}\right)^2$ on a section at the edge of the panel corresponding to the dimension $l_2$, and $\frac{1}{15}wl_1\left(l_2 - \frac{2c}{3}\right)^2$ at a section in the other direction. The limitations of the apportionment of moment between inner section and outer section and between mid-section and column-head sections may be the same as for square panels.

(*i*) *Wall Panels.*—The coefficient of negative moment at the first row of columns away from the wall should be increased 20 per cent over that required for interior panels, and likewise the coefficient of positive moment at the section halfway to the wall should be increased by 20 per cent. If girders are not provided along the wall or the slab does not project as a cantilever beyond the column line, the reinforcement parallel to the wall for the negative moment in the column-head section and for the positive moment in the outer section should be increased by 20 per cent. If the wall is carried by the slab this concentrated load should be provided for in the design of the slab. The coefficient of negative moments at the wall to take bending in the direction perpendicular to the wall line may be determined by the conditions of restraint and fixedness as found from the relative stiffness of columns and slab, but in no case should it be taken as less than one-half of that for interior panels.

(*j*) *Reinforcement.*—In the calculation of moments all the reinforcing bars which cross the section under consideration and which fulfill the requirements given under paragraph (*l*) of this chapter may be used. For a column-head section reinforcing bars parallel to the straight portion of the section do not contribute to the negative resisting moment for the column-head section in question. In the case of four-way reinforcement the sectional area of the diagonal bars multiplied by the sine of the angle between the diagonal of the panel and straight portion of the section under consideration may be taken to act as reinforcement in a rectangular direction.

(*k*) *Point of Inflection.*—For the purpose of making calculations of moments at sections away from the sections of negative moment and positive moment already specified, the point of inflection on any line parallel to a panel edge may be taken as one-fifth of the clear distance on that line between the two sections of negative moment at the opposite ends of the panel indicated in paragraph (*e*), of this chapter. For slabs having dropped panels the coefficient of one-fourth should be used instead of one-fifth.

(*l*) *Arrangement of Reinforcement.*—The design should include adequate provision for securing the reinforcement in place so as to take not only the maximum moments, but the moments at intermediate sections. All bars in rectangular bands or diagonal bands should extend on each side of a section of maximum moment, either positive or negative, to points at least twenty diameters beyond the point of inflection as defined herein or be hooked or anchored at the point of inflection. In addition to this provision bars in diagonal bands used as reinforcement for negative moment should extend on each side of a line drawn through the column center at right angles to the direction of the band at least a distance equal to thirty-five one-hundredths of the panel length, and bars in diagonal bands used as reinforcement for positive moment should extend on each side of a diagonal through the center of the panel at least a distance equal to thirty-five one-hundredths of the panel length; and no splice by lapping should be permitted at or near regions of maximum stress except as just described. Continuity of reinforcing bars is considered to have advantages, and it is recommended that not more than one-third of the reinforcing bars in any direction be made of a length less than the distance center to center of columns in that direction. Continuous bars should not all be bent up at the same point of their length, but the zone in which this bending occurs should extend on each side of the assumed point of inflection, and should cover a width of at least one-fifteenth of the panel length. Mere draping of the bars should not be permitted. In four-way reinforcement the position of the bars in both diagonal and rectangular directions may be considered in determining whether the width of zone of bending is sufficient.

(*m*) *Reinforcement at Construction Joints.*—It is recommended that at construction joints extra reinforcing bars equal in section to 20 per cent of the amount necessary to meet the requirements for moments at the section where the joint is made be added to the reinforcement, these bars to extend not less than 50 diameters beyond the joint on each side.

(*n*) *Tensile and Compressive Stresses.*—The usual method of calculating the tensile and compressive stresses in the concrete and in the reinforcement, based on the assumptions for internal stresses given in this chapter, should be followed. In the case of the dropped panel the section of the slab and dropped panel may be considered to act integrally for a width equal to the width of the column-head section.

(*o*) *Provision for Diagonal Tension and Shear.*—In calculations for the shearing stress which is to be used as the means of measuring the resistance to diagonal tension stress, it is recommended that the total vertical shear on two column-head sections constituting a width equal to one-half the lateral dimensions of the panel, for use in the formula for determining critical shearing stresses, be considered to be one-fourth of the total dead and live load on a panel for a slab of uniform thickness, and to be three-tenths of the sum of the dead and live loads on a panel for a slab with dropped panels. The formula for shearing unit stress may then be written $v = \frac{0.25W}{bjd}$ for slabs of uniform thickness, and $v = \frac{0.30W}{bjd}$ for slabs with dropped panels, where $W$ is the sum of the dead and live load on a panel, $b$ is half the lateral dimension of the panel measured from center to center of columns, and $jd$ is the lever arm of the resisting couple at the section.

The calculation of what is commonly called punching shear may be made on the assumption of a uniform distribution over the section of the slab around the periphery of the column capital and also of a uniform distribution over the section of the slab around the periphery of the dropped panel, using in each case an amount of vertical shear greater by 25 per cent than the total vertical shear on the section under consideration.

The values of working stresses should be those recommended for diagonal tension and shear in the section on "Working Stresses."

(*p*) *Walls and Openings.*—Girders or beams should be constructed to carry walls and other concentrated loads which are in excess of the working capacity of the lab. Beams should also be provided in case openings in the floor reduce the working strength of the slab below the required carrying capacity.

(*q*) *Unusual Panels.*—The coefficients, apportionments, and thicknesses recommended are for slabs which have several rows of panels in each direction, and in which the size of the panels is approximately the same. For structures having a width of one, two, or three panels, and also for slabs having panels of markedly different sizes, an analysis should be made of the moments developed in both slab and columns, and the values given herein modified accordingly. Slabs with paneled ceiling or with depressed paneling in the floor are to be considered as coming under the recommendations herein given.

(*r*) *Bending Moments in Columns.*—Provision should be made in both wall columns and interior columns for the bending moment which will be developed by unequally loaded panels, eccentric loading, or uneven spacing of columns. The amount of moment to be taken by a column will depend upon the relative stiffness of columns and slab, and computations may be made by rational methods, such as the principal of least work, or of slope and deflection. Generally, the larger part of the unequalized negative moment will be transmitted to the columns, and the column should be designed to resist this bending moment. Especial attention should be given to wall columns and corner columns.

## Working Stresses

**General Assumptions.**—The following working stresses are recommended for static loads. Proper allowances for vibration and impact are to be added to live loads where necessary to produce an equivalent static load before applying the unit stresses in proportioning parts.

In selecting the permissible working stress on concrete, the designer should be guided by the working stresses usually allowed for other materials of construction, so that all structures of the same class composed of different materials may have approximately the same degree of safety.

The following recommendations as to allowable stresses are given in the form of percentages of the ultimate strength of the particular concrete which is to be used; this ultimate strength is that developed at an age of twenty-eight days, in cylinders 8 inches in diameter and 16 inches long, of proper consistency[*] made and stored under laboratory conditions. In the absence of definite knowledge in advance of construction as to just what strength may be expected, the committee submits the following values as those which should be obtained with materials and workmanship in accordance with the recommendations of this report.

Although occasional tests may show higher results than those here given, the Committee recommends that these values should be the maximum used in design.

Table of Compressive Strengths of Different Mixtures of Concrete
(In Pounds per Square Inch)

| Aggregate | 1:3[†] | 1:4½[†] | 1:6[†] | 1:7½[†] | 1:9[†] |
|---|---|---|---|---|---|
| Granite, trap rock | 3300 | 2800 | 2200 | 1800 | 1400 |
| Gravel, hard limestone and hard sandstone | 3000 | 2500 | 2000 | 1600 | 1300 |
| Soft limestone and sandstone | 2200 | 1800 | 1500 | 1200 | 1000 |
| Cinders | 800 | 700 | 600 | 500 | 400 |

Note. For variations in the moduli of elasticity see 254.

**Bearing.**—When compression is applied to a surface of concrete of at least twice the loaded area, a stress of 35 per cent of the compressive strength may be allowed in the area actually under load.

**Axial Compression.**—For concentric compression on a plain concrete pier, the length of which does not exceed four diameters, or on a column reinforced with longitudinal bars only, the length of which does not exceed 12 diameters, 22.5 per cent of the compressive strength may be allowed.

For other forms of columns the stresses obtained from the ratios given in the preceding section on "Design" may govern.

**Compression in Extreme Fiber.**—The extreme fiber stress of a beam, calculated on the assumption of a constant modulus of elasticity for concrete under working stresses may be allowed to reach 32.5 per cent of the compressive strength. Adjacent to the support of continuous beams stresses 15 per cent higher may be used.

**Shear and Diagonal Tension.**—In calculations on beams in which the maximum shearing stress in a section is used as the means of measuring the resistance to diagonal tension stress, the following allowable values for the maximum vertical shearing stress in concrete, calculated by the method given in formula on page 4, $v = \frac{V}{bjd}$, are recommended:

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[*] The materials should be mixed wet enough to produce a concrete of such a consistency as will flow sluggishly into the forms and about the metal reinforcement, and which, at the same time, can be conveyed from the mixer to the forms without separation of the coarse aggregate from the mortar. The quantity of water is of the greatest importance in securing concrete of maximum strength and density; too much water is as objectionable as too little.

[†] Combined volume fine and coarse aggregate measured separately.

(*a*)—For beams with horizontal bars only and without web reinforcement, 2 per cent of the compressive strength.

(*b*)—For beams with web reinforcement consisting of vertical stirrups looped about the longitudinal reinforcing bars in the tension side of the beam and spaced horizontally not more than one-half the depth of the beam; or for beams in which longitudinal bars are bent up at an angle of not more than 45 degrees or less than 20 degrees with the axis of the beam, and the points of bending are spaced horizontally not more than three-quarters of the depth of the beam apart, not to exceed 4½ per cent of the compressive strength.

(*c*)—For a combination of bent bars and vertical stirrups looped about the reinforcing bars in the tension side of the beam and spaced horizontally not more than one-half of the depth of the beam, 5 per cent of the compressive strength.

(*d*)—For beams with web reinforcement (either vertical or inclined) securely attached to the longitudinal bars in the tension side of the beam in such a way as to prevent slipping of bar past the stirrup, and spaced horizontally not more than one-half of the depth of the beam in case of vertical stirrups and not more than three-fourths of the depth of the beam in the case of inclined members, either with longitudinal bars bent up or not, 6 per cent of the compressive strength.

The web reinforcement in case any is used should be proportioned by using two-thirds of the external vertical shear in formulas (*a*) and (*b*) on page 4. The effect of longitudinal bars bent up at an angle of from 20 to 45 degrees with the axis of the beam may be taken at sections of the beam in which the bent up bars contribute to diagonal tension resistance (see "Diagonal Tension and Shear," page 245) as reducing the shearing stresses to be otherwise provided for. The amount of reduction of the shearing stress by means of bent up bars will depend upon their capacity, but in no case should be taken as greater than 4½ per cent of the compressive strength of the concrete over the effective cross-section of the beam.* The limit of tensile stress in the bent up portion of the bar calculated by formula (*b*) on page 4, using in this formula an amount of total shear corresponding to the reduction in shearing stress assumed for the bent up bars, may be taken as specified for the working stress of steel, but in the calculations the stress in the bar due to its part as longitudinal reinforcement of the beam should be considered. The stresses in stirrups and inclined members when combined with bent up bars are to be determined by finding the amount of the total shear which may be allowed by reason of the bent up bars, and subtracting this shear from the total external vertical shear. Two-thirds of the remainder will be the shear to be carried by the stirrups, using formulas (*a*) or (*b*) on page 4.

Where punching shear occurs, provided the diagonal tension requirements are met, a shearing stress of 6 per cent of the compressive strength may be allowed.

**Bond.**—The bond stress between concrete and plain reinforcing bars may be assumed at 4 per cent of the compressive strength, or 2 per cent in the case of drawn wire. In the best types of deformed bar the bond stress may be increased, but not to exceed 5 per cent of the compressive strength of the concrete.

**Reinforcement.**—The tensile or compressive stress in steel should not exceed 16,000 pounds per square inch.

In structural steel members the working stresses adopted by the American Railway Engineering Association are recommended.

**Modulus of Elasticity.**—The value of the modulus of elasticity of concrete has a wide range, depending on the materials used, the age, the range of stresses between which it is considered, as well as other conditions. It is recommended that in computations for the position of the neutral axis, and for the resisting moment of beams and for compression of concrete in columns, it be assumed as:

(*a*)—One-fortieth that of steel, when the strength of the concrete is taken as not more than 800 pounds per square inch.

(*b*)—One-fifteenth that of steel, when the strength of the concrete is taken as greater than 800 pounds per square inch.

(*c*)—One-twelfth that of steel, when the strength of the concrete is taken as greater than 2,200 pounds per square inch, and less than 2,900 pounds per square inch.

(*d*)—One-tenth that of steel, when the strength of the concrete is taken as greater than 2,900 pounds per square inch.

Although not rigorously accurate, these assumptions will give safe results. For the deflection of beams which are free to move longitudinally at the supports, in using formulas for deflection which do not take into account the tensile strength developed in the concrete, a modulus of one-eighth of that of steel is recommended.

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* $v = \frac{V}{bjd}$.

## AMERICAN CONCRETE INSTITUTE RECOMMENDATIONS*

**1. Conditions.**—All reinforced-concrete construction shall be designed to meet the conditions of loading (including bending in columns) without stressing the materials used beyond the safe working stresses specified.

**2. Dead-Loads.**—The dead-loads shall be the weight of the permanent structure. The weight of reinforced stone, gravel or slag concrete shall be taken as 144 lb. per cu. ft.; the weight of cinder concrete as 100 lb. per cu. ft.

**3. Live-Loads.**—The live-load shall be the working or variable load for which the structure is designed.

**4. Reduction of Loads.**—All parts of a structure shall be designed to carry safely the entire combined dead- and live-loads with the exception that the loads on columns and foundations may be reduced by considering that columns in top story carry the total live- and dead-load above them; columns in next to top story carry the total dead-load and eighty-five (85) per cent of the total live-load above; columns in the next lower story, the total dead-load and eighty (80) per cent of the total live-load above: and thus on downward reducing at each story the percentage of total live-loads carried, by 5, until a reduction of fifty (50) per cent is reached. The columns in this and in every story below this point shall be proportioned to carry the total dead-load and at least fifty (50) per cent of the total live-load of all the floors and roofs above them.

For warehouses the increment of reduction per story shall be 2½ per cent instead of 5 per cent.

**5. General Assumptions.**—As a basis for calculations for the strength of reinforced-concrete construction the following assumptions shall be made:

(*a*) Calculations shall be made with reference to working stresses and safe loads rather than with reference to ultimate strength and ultimate loads.

(*b*) A plane section before bending remains plane after bending.

(*c*) The modulus of elasticity of concrete in compression within the usual limits of working stresses is constant.

(*d*) In calculating the moment of resistance of beams, the tensile stresses in the concrete are neglected.

(*e*) Perfect adhesion is assumed between concrete and reinforcement. Under compressive stresses the two materials will, therefore, be stressed in proportion to their moduli of elasticity.

(*f*) The ratio of the modulus of elasticity of concrete shall be taken as follows:

1. One-fortieth that of steel when the strength of the concrete is taken as not more than eight hundred (800) lb. per sq. in.
2. One-fifteenth that of steel when the strength of the concrete is taken as greater than twelve hundred (1200) lb. per sq. in. or less than twenty-two hundred (2200) lb. per sq. in.
3. One-twelfth that of steel when strength of the concrete is taken as greater than twenty-two hundred (2200) lb. per sq. in. or less than thirty-three hundred (3300) lb. per sq. in.
4. One-tenth that of steel when the strength of the concrete is taken as greater than thirty-three hundred (3300) lb. per sq. in.

**6. Strength of Materials.**—The ultimate strength of concrete shall be that developed at an age of 28 days, in cylinders 8 in. in diameter and 16 in. in length or 6 in. in diameter and 12 in. in length, of the consistency and proportions to be used in the work, made and stored under laboratory conditions, but in no case shall the values exceed those allowed in the table below. In the absence of definite knowledge in advance of construction as to just what strength may be developed, the following values may be used:

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* Passed by letter-ballot of the Institute, April 17, 1920.

### Table of Strengths of Different Mixtures

| | Proportion of cement to aggregate | | | | |
|---|---|---|---|---|---|
| Aggregate | 1:3* | 1:4½* | 1:6* | 1:7½* | 1:9* |
| For stone, gravel or slag with water-cement ratio† of | 0.8 | 0.9 | 1.0 | 1.11 | 1.22 |
| Strength of concrete | 3000 | 2500 | 2000 | 1600 | 1300 |
| Cinders | 800 | 700 | 600 | 500 | 400 |

**7. Safe Working Stresses.**—Reinforced-concrete structures shall be so designed that the stresses, figured in accordance with these regulations, in pounds per square inch, shall not exceed the following:

(*a*) Extreme fiber stress in concrete in compression 37½ per cent of the compressive strength specified in Section 6. Adjacent to the support of continuous members, 41 per cent provided the member frames into a mass of concrete projecting at least 50 per cent of the least dimension of the member on all sides of the compression area of the member.

(*b*) Concrete in direct compression 25 per cent of the compressive strength specified in Section 6.

(*c*) Shearing stress in concrete when main steel is not bent and when steel is not provided to resist diagonal tension, as specified in Section 10.

(*d*) Where punching shear occurs, provided the diagonal tension requirements are met, a shearing stress as specified in Section 10 will be allowed.

(*e*) Vertical shearing stresses, as specified in Section 10.

(*f*) Bond stress between concrete and plain reinforcing bars—4 per cent of the compressive strength.

(*g*) Bond stress between concrete and approved deformed bars—5 per cent of the compressive strength.

(*h*) Compression applied to a surface of concrete of at least twice the loaded area, a stress of 50 per cent of the compressive strength shall be allowd over the area actually under load.

(*i*) Tensile stress in steel—16,000 lb. per sq. in., except that for steel having an elastic limit of at least 50,000 lb., a working stress of 18,000 lb. per sq. in. will be allowed.

**8. Girder, Beam, and Slab Construction.**—In determining the bending moment in slabs, beams and girders, the load carried by the member shall include both the dead- and the live-loads.

The span of the member shall be the distance center to center of supports, but not to exceed the clear span plus the depth of the member, except that for continuous or fixed members framing into other reinforced-concrete members the clear span may be used.

For continuous members supported upon brackets making an angle of not more than 45 degrees with the vertical, and having a width not less than the width of the member supported, the span shall be the clear distance between brackets plus one-half the total depth of the member.

If the brackets make a greater angle than 45 degrees with the vertical, only that portion of the bracket within the 45 degrees slope shall be considered. Maximum negative moments are to be considered as existing at the end of the span as here defined.

For members uniformly loaded the bending moment shall be assumed as $\frac{WL}{F}$, where $W$ = total load; $L$ = span; and $F$ = 8 for members simply supported, 10 for both negative and positive bending moment for members restrained at one end and simply supported or partially restrained at the other, and 12 for both negative and positive bending moment for members fixed or continuous at both supports. The above bending moments for continuous members apply only when adjacent spans are approximately equal.

A special condition of loading to be reduced to equivalent uniformly distributed loading in accordance with approved engineering practice. For members having one end simply supported or partially restrained, at least fifty (50) per cent of the tension reinforcement required at center of span shall be bent up and adequately anchored to take bending moment at exterior support.

At the ends of continuous beams, the amount of negative moment which will be developed in the beam will depend on the condition of restraint or fixedness, and this will depend on the form of construction used. In the ordinary cases a moment of $\frac{w^2}{16}$ may be taken; for small beams running into heavy columns this should be increased but not to exceed $\frac{w^2}{12}$.

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* Total volume of fine and coarse aggregate, measured separately.

† Water-Cement Ratio = Ratio of water to cement by volume.

**9. Slabs.**—The main tensile reinforcement shall not be farther apart than two times the thickness of the slab. For slabs designed to span one way, steel having an area of at least two-tenths of one per cent (0.2 %) of section of slab shall be provided transverse to main reinforcement, and this transverse reinforcement shall be further increased in the top of the slab over girders to prevent cracking, and the main steel in slabs parallel and adjacent to girders may be reduced accordingly. Where openings are left through slabs, extra reinforcement shall be provided to prevent local cracks developing. This reinforcement shall in no case be less than ¼ sq. in. in section and must be securely anchored at ends. Floor finish when placed monolithic may be considered part of the structural section.

Where adequate bond and shearing resistance between slab and web of beam is provided, the slab may be considered as an integral part of the beam, but its effective width shall not exceed on either side of the beam one-sixth of the span length of the beam nor be greater than six times the thickness of the slab on either side of the beam, nor greater than one-half of the distance between beams on either side, the measurements being taken from edge of web.

**10. Shear and Diagonal Tension.**—(*a*) The notation used in this section is as follows:

$V$ = total vertical shear at any section.
$V'$ = vertical shear carried by the web reinforcement.
$v = V/bjd$ = Unit vertical shearing stress.
$d$ = depth from compressive face to c. g. of tensile steel in inches.
$b$ = breadth of beam.
$b'$ = breadth of stem of T-beam or web of I-beam.
$A_s$ = area of longitudinal steel.
$A_v$ = area of shear steel in section of beam considered.
$j$ = ratio of lever arm of resistance couple to depth $d$.
$p = A_s/bd$ = Longitudinal steel ratio.
$r = A_v/ba$ = Shear steel ratio.
$a$ = spacing of shear steel measured perpendicular to its direction.
$f_c'$ = ultimate strength of concrete cylinders at 28 days (or at time of test in considering test data).
$f_v$ = tensile stress in web reinforcement.

Except where $v$ is noted as the unit punching shearing stress, it is used as a shearing stress index governing the value of the diagonal tension in the web as is the present common practice.

(*b*) All allowances for design unit shearing stresses in the following sections are predicated on proper design of the longitudinal reinforcement to effectively resist all positive and negative moments, as prescribed in other sections of these standards. Wherever web reinforcement is used it must be adequately anchored at both ends.

(*c*) *Members with Web Reinforcement.*—When adequate mechanical anchorage of both web and longitudinal rods is provided, the concrete may be figured to carry a unit vertical shearing stress equal to $0.025f_c'$ and the remainder of the shear shall be carried by web bars designed according to the formula:

$$A_v = \frac{V'a}{f_v jd}$$

Properly anchored bent-up longitudinal bars may be considered as web reinforcement. The maximum unit shearing stress shall not exceed $0.12f_c'$ in any case.

(*d*) When adequate mechanical anchorage of the longitudinal rods as defined in the next paragraph is not provided, the maximum unit shearing stress shall not exceed $0.06f_c'$, of which $0.02f_c'$ may be considered to be taken by the concrete and the remainder of the shear taken by the web bars designed as above. Web rods must be adequately anchored in all cases.

(*e*) Adequate mechanical anchorage of the bottom longitudinal steel for positive moments shall consist of carrying the reinforcement a sufficient distance beyond the point of inflection to develop the assumed tension in the reinforcement at the point of inflection by bond between the end of the bar and the point of inflection of the member (never to a less distance than one inch from the center of the support or in case of wide supports to not less than 12 in. of embedment in the support), or of bending the end of the bars over the support to a half circle of diameter not less than 8 times the diameter of the bar, or by any device that will transmit the tension on the bar to the concrete over the support at a compressive stress of not over $0.50f_c'$. The tension in the bar, at the point of inflection to be resisted by the anchorage, shall be taken for this computation as not less than one-third of the maximum safe tension in the bar. Reinforcement for negative moment shall be thoroughly anchored at the support and extend into the span a sufficient distance to adequately provide for negative tension by bond. Simply supported beams shall have the longitudinal steel anchored by hooks of diameter specified above or by an equivalent anchorage, the tensile stress at the edge of the support being taken as one-third of the maximum safe tension in the bar. (Figs. 1, 2 and 3.)

(*f*) Anchorage of the web steel shall consist of continuity of the web member with the longitudinal member, or of carrying the web member about at least two sides of a longitudinal bar at both ends, or of carrying the web member about at least two sides of a longitudinal member at one end and making a half circular hook at the other end of a diameter not less than eight times the diameter of the web rod. In all cases, the bent ends of web bars shall extend at least eight diameters below or above the point of extreme height or depth of the bar. In case the end anchorage is not in bearing on other reinforcing steel, the anchorage shall be such as to engage an adequate amount of concrete to prevent the bar from pulling off a portion of the concrete. In all cases the stirrups shall be carried as close to the upper and lower surfaces as fireproofing requirements will permit. The size of web reinforcing bars which are not either a part of the longitudinal steel or welded thereto shall be such that not less than two-fifths of the maximum design tensile stress in the bar may be developed at design bond stresses in a length of rod equal to $0.4d$. This condition is satisfied for plain

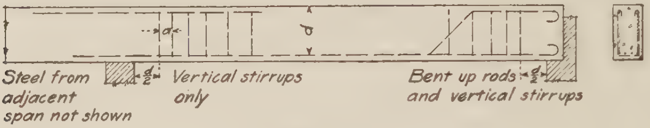


FIG. 1.

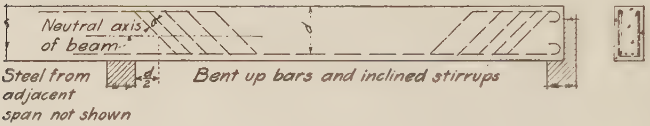

Neutral axis of beam
d
Steel from adjacent span not shown
d/2
Bent up bars and inclined stirrups

FIG. 2.

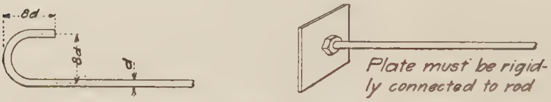


FIG. 3.

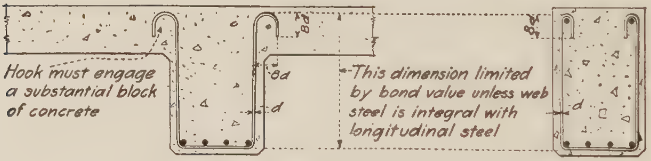

Hook must engage a substantial block of concrete
8d
d
This dimension limited by bond value unless web steel is integral with longitudinal steel
d

FIG. 4.

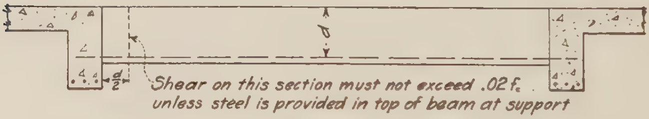

d
d/2
Shear on this section must not exceed .02 f_c unless steel is provided in top of beam at support

FIG. 5.

round stirrups when the diameter of the bar does not exceed $d/50$. The balance of the tensile stress in the bar may be considered as taken by adequate end anchorage as specified above. (Fig. 4.)

(*g*) Beams in which no longitudinal reinforcement is provided in the upper portion of the beam adjacent to the support and in which the ends of the beam are built monolithic with other parts of the concrete structure, shall not carry a unit shearing stress in excess of $0.02f_c'$, regardless of amount of web reinforcement provided. (Fig. 5.)

(*h*) When the shear reinforcement consists of bars bent up at an angle so as to reinforce all sections of the beam in which the unit shearing stress exceeds $0.02f_c'$ the design may be made as follows:

$$A_v f_v = V' \sec \alpha.$$

Where $A_v$ = area of bent-up shear bars.
$f_v$ = stress in bent-up shear bars.
$V'$ = total shear at end of span as prescribed for moment less the shearing resistance of the concrete at a unit stress of $0.02f_c'$ over the area $b'jd$.
$\alpha$ = angle between bent-up rod and the vertical. (Fig. 6.)

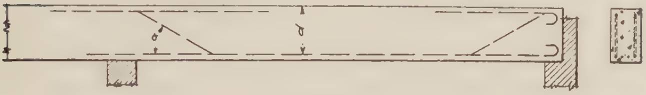


FIG. 6.

The maximum unit shearing stress shall not exceed $0.06 f_c'$ with this arrangement of web steel and the longitudinal steel shall be adequately anchored as defined above in all cases.

(*i*) In case the web reinforcement consists solely of inclined shear bars the first bent bar shall bend downward from the plane of the upper reinforcement directly over or within the edge of the support.

(*j*) Where additional web reinforcement is provided the same may be figured in accordance with Section 10 (*c*). The total shearing resistance of the beam shall be taken as the sum of the resistances under Section 10 (*c*) and 10 (*h*).

(*k*) *Beams without Web Reinforcement.*—When the longitudinal steel is not fully anchored, as prescribed above, the unit shearing stress shall not exceed $0.02f_c'$. When the longitudinal steel is fully anchored, as prescribed above, the unit shearing stress shall not exceed $0.03f_c'$.

(*l*) *Critical Section for Shear in Beams.*—The critical section for shear as governing diagonal tension shall be taken at a distance not greater than one-half the effective depth of the beam ($\frac{1}{2}d$), from the end of the span as prescribed for moment.

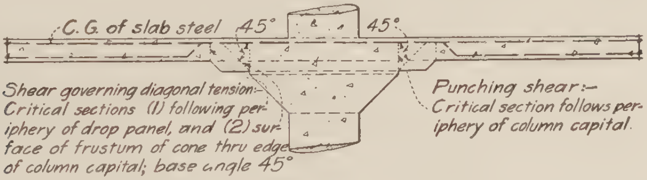

C. G. of slab steel
45°
45°
Shear governing diagonal tension:-
Critical sections (1) following periphery of drop panel, and (2) surface of frustum of cone thru edge of column capital; base angle 45°
Punching shear:-
Critical section follows periphery of column capital.

FIG. 7.

The effective depth of the critical section for shear as governing diagonal tension shall be taken as the depth *jd* of the beam in the plane of the critical section.

The breadth of the critical section shall be the full breadth of rectangular beams or the breadth of the stem of T-beams or the thickness of the web in beams of I section.

(*m*) *Tile and Concrete Joist Construction.*—The shearing stresses in tile and concrete joist construction shall not exceed those in beams or slabs of similar reinforcement. The breadth of the effective section for shear, as governing diagonal tension, may be taken as the thickness of the concrete joist plus one-half the thickness of the vertical webs of the tile, provided that the joints in one row come opposite the centers of tile in adjoining rows on either side.

Where the tile joints are not staggered, only the concrete joists may be considered effective in resisting shear.

(*n*) *Flat-slab Construction.*—In flat-slab construction where a drop panel is used adjoining the column, the shearing stress, as governing diagonal tension, figured on the $jd$ depth on a vertical section along the periphery of the drop, shall not exceed $0.03f_c'$. (See Fig. 7.)

(*o*) In flat-slab construction, with or without drop panels, the shearing stress, as governing diagonal tension, figured between the compression face of the slab or drop and the level of the center of gravity of the reinforcing steel, on the surface of the frustum of a cone or pyramid passing through the periphery of the column capital and having a base angle of 45 degrees, shall not exceed $0.035f_c'$.

(*p*) *Footings.*—In footings carrying a single column or load, the shearing stress, as governing diagonal tension, figured between the level of the centroid of the compressive stresses and the level of the center of gravity of the reinforcing steel on the surface of the frustum of a cone or pyramid passing through the base of the supported column or loaded member and having a base angle of 45 degrees the unit stresses shall not exceed those in beams without web reinforcement. Especial attention shall be given to bond in footings. The total vertical shear on this section shall be taken as the upward pressure on the area of the footing outside the base of this section.

(*q*) If adequate anchorage is provided for the tensile steel and adequately anchored web reinforcement is also provided such web reinforcement may be figured in accordance with the formula given in Section 10 (*c*) above. Such calculations may be made for vertical sections concentric with the supported column.

(*r*) For footings supporting two or more columns, the shearing stresses shall be figured as for beams or slabs.

(*s*) *Arrangement of Web Reinforcement.*—The spacing of web reinforcement as measured perpendicular to their direction shall not exceed $3d/4$ in any case where web reinforcement is necessary. Where vertical stirrups or web members inclined less than 30 degrees to the vertical are used, the spacing shall not exceed $d/2$. When the unit shearing stress exceeds $0.06f_c'$ the spacing of the web reinforcement shall not exceed $d/2$ in any case, nor $d/3$ for vertical stirrups or web steel inclined less than 30 degrees with the vertical.

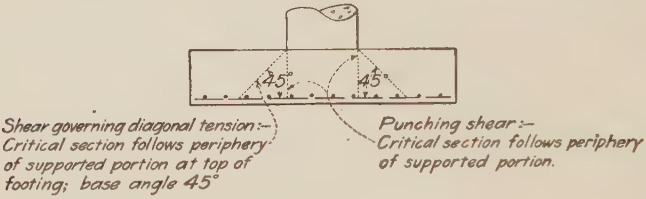

45°
45°
Shear governing diagonal tension:—Critical section follows periphery of supported portion at top of footing; base angle 45°
Punching shear:—Critical section follows periphery of supported portion.

FIG. 8.

The first vertical stirrup shall be placed not farther than $d/2$ from the face of the support in any case. The first inclined stirrup or bent-up rod shall reach the level of the upper longitudinal steel at a distance not greater than $d/2$ from the edge of the support if the bottom longitudinal steel is adequately anchored and at the edge of the web support if the longitudinal steel is not anchored. Web members may be placed at any angle between 0 and 60 degrees with the vertical, provided that, if inclined, they shall be inclined in the proper direction to take tension, rather than compression, in the web.

(*t*) *Punching Shear.*—Punching shear shall be figured on a vertical section through the periphery of the smaller member. The unit shearing stress in punching shear, figured on the full depth $d$ to the center of gravity of the reinforcement, shall not exceed $0.1f_c'$.

(*u*) When the depth of the supported or supporting member is less than one-fifteenth of the span in the case of beams or slabs, or less than one-third of the overhang in the case of cantilevers (including footings), the unit shearing stress in punching shear shall not exceed $0.06f_c'$.

**11. Tile and Joist Floors.**—Wherever floors are built with a combination of tile or other fillers between reinforced-concrete joists, the following rules regarding the dimensions and methods of calculations of construction shall be observed:

(*a*) Wherever a portion of the slab above the fillers is considered as acting as a T-beam section, the slab portion must be cast monolithic with the joist and have a minimum thickness of two (2) inches.

(*b*) Wherever porous fillers are used which will absorb water from the concrete, care must be taken thoroughly to saturate same before concrete is placed.

(*c*) All regulations given above for beam and girder floors shall apply to tile and joist floors.

(*d*) The sections of fillers shall be together and all joints reasonably tight before concrete is placed.

**12. Flat-slab or Girderless Floors.**—Continuous flat-slab floors, reinforced with steel rods or mesh and supported on spaced columns in orderly arrangement, shall conform to the following requirements:

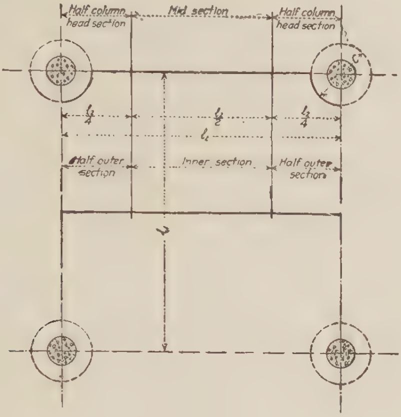
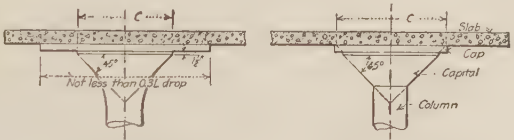


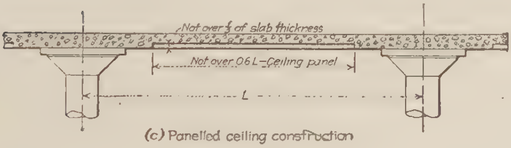
FIG. 9.

(*a*) *Notation and Nomenclature.*—In the formula let

$w$ = total dead-and live-load in pounds per square foot of floors.
$l_1$ = span in feet center to center of columns parallel to sections on which moments are considered.
$l_2$ = span in feet center to center of columns perpendicular to sections on which moments are considered.
$c$ = average diameter of column capital in feet at plane where its thickness is $1\frac{1}{2}$ in.
$q$ = distance from center line of the capital to the center of gravity of the periphery of the half capital divided by $\frac{1}{2}c$. For round capitals $q$ may be considered as two-thirds and for square capitals as three-quarters.
$t$ = total slab thickness in inches.
$L$ = average span in feet center to center of columns, but not less than 0.9 of the greater span.



(*a*) Drop construction (*b*) Cap construction


Not over $\frac{1}{3}$ of slab thickness
Not over 0.6 L—Ceiling panel
L

(*c*) Panelled ceiling construction

FIG. 10.

The column head section, mid section, outer section, and inner section are located and dimensioned as shown in Fig. 9. Corresponding moments shall be figured on similar sections at right angles to those shown in Fig. 9.

(*b*) *Structural Variations.*—Flat-slab floors may be built with or without caps, drops or paneled ceilings. These terms are illustrated in Fig. 10.

Where caps are employed they shall be considered a part of the columns and the column capital dimension $c$ shall be found by extending the lines of the capital to an intersection with the plane of the under surface of the slab as indicated in Fig. 10*b*. The cap shall be large enough to enclose this extension of the capital lines.

The column capital profile shall not fall at any point inside an inverted cone drawn, as shown in Fig. 10*a*, from the periphery of the designed capital of diameter $c$ and with a base angle of 45 degrees. The diameter of the designed capital $c$ shall be taken where the vertical thickness of the column capital is at least 1½ in.

The drop, where used, shall not be less than 0.3 $L$ in width.

Where paneled ceilings are used the paneling shall not exceed one-half of the slab thickness in depth and the dimension of the paneling shall not exceed 0.8 of the panel dimension. (See Fig. 10*c*.)

(*c*) *Slab Thickness.*—The slab thickness shall not be less than $t = 0.02L\sqrt{w} + 1$ *in.*

In no case shall the slab thickness be less than $\frac{1}{32}L$ for floor slabs nor less than $\frac{1}{40}L$ for roof slabs.

(*d*) *Design Moments.*—The numerical sum of the positive and negative moments in foot pounds shall not be less than $0.09wl_1(l_2 - qc)^2$. Of this total amount not less than 40 per cent shall be resisted in the column head sections. Where a drop is used, not less than 50 per cent shall be resisted in the column head sections.

Of the total amount not less than 10 per cent shall be resisted in the mid section.

Of the total amount not less than 18 per cent shall be resisted in the outer section.

Of the total amount not less than 12 per cent shall be resisted on the inner sections.

The balance of the moment shall be distributed between the various sections as required by the physical details and dimensions of the particular design employed.

(*e*) *Exterior Panels.*—The negative moments at the first interior row of columns and the positive moments at the center of the exterior panel on sections parallel to the wall, shall be increased 20 per cent over those specified above for interior panels. If girders are not provided long the column line, the reinforcement parallel to the wall for negative moment in the column head section and for positive moment in the outer section adjacent to the wall, shall be altered in accordance with the change in the value of $c$. The negative moment on sections at the wall and parallel thereto should be determined by the conditions of restraint, but must never be taken less than 80 per cent of those for the interior panels.

(*f*) *Reinforcement.*—In the calculation of moments all the reinforcing bars which cross the section under consideration and which fulfill the requirements given under "Arrangement of Reinforcement" may be used. For a column head section reinforcing bars parallel to the straight portion of the section do not contribute to the negative resisting moment for the column head section in question. The sectional area of bars, crossing the section at an angle, multiplied by the sine of the angle between these bars and the straight portion of the section under consideration may be taken to act as reinforcement in a rectangular direction. Calculations for shearing stress shall be made in accordance with Section 10.

(*g*) *Point of Inflection.*—For the purpose of making calculations of moment at sections away from the sections of negative moment and positive moment already specified, the point of inflection shall be taken at a distance from center line of columns equal to $\frac{1}{5}(l_2 - qc) + \frac{1}{2}qc$. This becomes $\frac{1}{5}(l_2 + c)$ where capital is circular. For slabs having drop panels the coefficient of $\frac{1}{4}$ should be used instead of $\frac{1}{5}$.

(*h*) *Arrangement of Reinforcement.*—The design should include adequate provision for securing the reinforcement in place so as to take not only the maximum moments but the moments of intermediate sections. If bars are extended beyond the column capital and are used to take the bending moment on the opposite side of the column, they must extent to the point of inflection. Bars in diagonal bands used as reinforcement for negative moment should extend on each side of the line drawn through the column center at right angles to the direction of the band a distance equal to 0.35 of the panel length, and bars in the diagonal bands used as reinforcement for positive moment, should extend on each side of the diagonal through the center of the panel a distance equal to 0.35 of the panel length. Bars spliced by lapping and counted as only one bar in tension shall be lapped not less than 80 diameters if splice is made at point of maximum stress and not more than 50 per cent of the rods shall be so spliced at any point in any single band or in any single region of tensile stress. Continuous bars shall not all be bent up at the same point of their length, but the zone in which this bending occurs should extend on each side of the assumed point of inflection.

(*i*) *Tensile and Compressive Stresses.*—The usual method of calculating the tensile and compressive stresses in the concrete and in the reinforcement, based on the assumptions for internal stresses, should be followed. In the case of the drop panel, the section of the slab and drop panel may be considered to act integrally for a width equal to a width of the column head section. Within the column head section the allowable compression may be increased as prescribed in Section 7 for continuous members.

(*j*) *Provision for Diagonal Tension and Shear.*—In calculations for the shearing stress which is to be used as the means for measuring the resistance to diagonal tension stress, it shall be assumed that the total vertical shear on a column head section constituting a width equal to one-half the lateral dimension of the panel, for use in determining critical shearing stresses, shall be considered to be one-fourth of the total dead- and live-load on a panel for a slab of uniform thickness, and to be 0.3 of the sum of the dead- and live-loads on a panel for a slab with drop panels. The formula for shearing unit stress shall be $v = \frac{0.25W}{bjd}$ for slabs of uniform thickness and $v = \frac{0.30W}{bjd}$ for slabs with drop panels, where $W$ is the sum of the dead- and live-load on a panel, $b$ is half the lateral dimension of the panel measured from center to center of columns, and $jd$ is the lever arm of the resisting couple at the section.

The calculation for punching shear shall be made on the assumption of a uniform distribution over the section of the slab around the periphery of the column capital and also of a uniform distribution over the section of the slab around the periphery of the drop panel, using in each case an amount of vertical shear greater by 25 per cent than the total vertical shear on the section under consideration.

The values of working stresses should be those recommended for diagonal tension and shear in Section 10.

(*k*) *Walls and Openings.*—Additional slab thickness, girders, or beams shall be provided to carry walls and other concentrated loads which are in excess of the working capacity of the slab. Beams should also be provided in case openings in the floor reduce the working strength of the slab below the required carrying capacity. Where lintels are used with flat-slab construction the depth of the lintels being greater than the combined depth of the slab and depressed panel, they shall be designed to carry a uniformly distributed load equal to $\frac{1}{8}$ of the total panel load in addition to any other loads superimposed upon the lintel and the dead weight of the lintel.

(*l*) *Unusual Panels.*—The coefficients, steel distribution, and thicknesses recommended are for slabs which have three or more rows of panels in each direction and in which the sizes of the panels are approximately the same. For structures having a width of one or two panels, and also for slabs having panels of markedly different sizes, an analysis should be made of the moments developed in both slab and columns and the values given herein modified accordingly.

(*m*) *Oblong Panels.*—The requirements of design herein given for flat-slab floors do not apply for oblong panels where the long side is more than four-thirds of the short side.

(*n*) *Bending Moments in Columns.*—Provision shall be made in both wall columns and interior columns for the bending moment which will be developed by unequally loaded panels, eccentric loading, or uneven spacing of columns. The amount of moment to be taken by a column will depend on the relative stiffness of columns and slab, and computations may be made by rational methods such as the principle of least work or of slope and deflection. Generally the largest part of the unequalized negative moment will be transmitted to the columns and the columns shall be designed to resist this bending moment. Especial attention shall be given to wall columns and corner columns. Column capitals shall be designed, and reinforced where necessary, with these conditions in mind.

The resistance of any wall column to bending in a direction perpendicular to the wall shall be not less than $0.04\ wl_1(l_2 - qc)^2$ in which $l_2$ is the panel dimension perpendicular to the wall. The moment in such wall column may be reduced by the balancing moment of the weight of the structure which projects beyond the center line of the supporting wall column.

Where the column extends through the story above, the resisting moment shall be divided between the upper and the lower columns in proportion to their stiffness. Calculated combined stresses due to bending and direct load shall not exceed by more than 50 per cent the stresses allowed for direct load.

**13. Columns—General.**—Reinforced-concrete columns, for the working stresses hereinafter specified, shall have a gross width or diameter not less than one-fifteenth of the unsupported height nor less than twelve (12) in. All vertical reinforcement shall be secured against lateral displacement by steel ties not less than $\frac{1}{4}$ in. in diameter, placed not farther apart than 15 diameters of the vertical rods or more than 12 in.

For columns supporting flat-slab floors or roofs, the diameter shall be not less than one-thirteenth of the distance between columns.

The length of columns shall be taken as the maximum unstayed length.

**14. Columns with Longitudinal Reinforcement.**—For columns having not less than 0.5 per cent nor more than 4 per cent of vertical reinforcement, the allowable working unit stress for the net section of the concrete shall be 25 per cent of the compressive strength specified in Section 6, and the working unit stress for the steel shall be based upon the ratio of the moduli of elasticity of the concrete and steel. Concrete to a depth of $1\frac{1}{2}$ in. shall be considered as protective covering and not a part of the net section.

**15. Columns with Longitudinal and Lateral Reinforcement.**—Columns, having not less than 1 per cent nor more than 4 per cent of vertical reinforcement and not less than 0.5 per cent nor more than 2 per cent of lateral reinforcement in the form of hoops or spirals spaced not farther apart than one-sixth of the outside diameter of the hoops or spirals nor more than 3 in. shall have an allowable working unit stress for the concrete within the outside diameter of the hoops or spirals equal to 25 per cent of the compressive strength of the concrete, as given in Section 6, and a working unit stress on the vertical reinforcement equal to the working value of the concrete multiplied by the ratio of the specified moduli of elasticity of the steel and concrete, and a working load for the hoops or spirals determined by considering the steel in hoops or spirals as four times as effective as longitudinal reinforcing steel of equal volume. The percentage of lateral reinforcement shall be taken as the volume of the hoops or spirals divided by the volume of the enclosed concrete in a unit length of column. The hoops or spirals shall be rigidly secured at each intersection to at least four (4) verticals to insure uniform spacing. The percentage of longitudinal reinforcement used shall be not less than the percentage of the lateral reinforcement. Spirals shall be manufactured of steel having a yield point of not less than 50,000 lb. per square inch.

**16.** For steel columns filled with concrete and encased in a shell of concrete at least 3 in. thick, where the steel is calculated to carry the entire load, the allowable stress per square inch shall be determined by the following formula: $18{,}000 - 70\frac{L}{R}$, but shall not exceed 16,000 lb.—where $L$ = unsupported length in inches and $R$ = least radius of gyration of steel section in inches. The concrete shell shall be reinforced with wire mesh or hoop weighing at least 0.2 lb. per square foot of surface of shell.

When the details of the structural steel are such as to fully enclose or encase the concrete, or where a spiral of not less than one-half of 1 per cent of the core area, and with a pitch of not more than 3 in., is provided for this purpose, the concrete inside the column core or spiral may be loaded to not more than 25 per cent of the ultimate strength specified in Section 6, in addition to the load on the steel column figured as above.

Composite columns having a cast iron core or center surrounded by concrete which is enclosed in a spiral of not less than one-half of 1 per cent of the core area, and with a pitch of not more than 3 in. may be figured for a stress of $12{,}000 - 60L/R$, but not over 10,000 lb. per square inch on the cast iron section and of not more than 25 per cent of the compressive strength specified in Section 6 on the concrete within the spiral or core. The diameter of the cast iron core shall not exceed one-half of the diameter of the spiral.

**17. Footings—General.**—Symmetrical, concentric column footings shall be designed for punching shear, diagonal tension, and bending moment.

**18. Punching Shear in Footings.**—Punching shear shall be figured in accordance with Section 10.

**19. Diagonal Tension in Footings.**—Shearing stresses shall be figured in accordance with Section 10.

**20. Bending Moment in Footings.**—The bending moment in isolated column footings at a section taken at edge of pier or column shall be determined by multiplying the load on the quarter footing (after deducting the quarter pier or column area) by six-tenths of the distance from the edge of pier or column to the edge of footing. The effective area of concrete and steel to resist bending moment shall be considered as that within a width extending both sides of pier or column, a distance equal to depth of footing plus one-half the remaining distance to edge of footing, except that reinforcing steel crossing the section other than at right angles, shall be considered to have an effective area determined by multiplying the section area by the line of the angle between the bar and the plane of section.

**21. Bond Stresses in Footings.**—In designing footings, careful consideration must be given to the bond stresses which will occur between the reinforcing steel and the concrete.

**22. Walls—General.**—Walls shall be reinforced by steel rods running horizontally and vertically. Walls having an unsupported height not exceeding fifteen times the thickness may be figured the same as columns. Walls having an unsupported height not more than twenty-five times the thickness may be figured to carry safely a working stress of 12½ per cent of the compressive strength specified in Section 6.

**23. Exterior Walls.**—Exterior walls shall be designed to withstand wind loads or loads from backfill. The thickness of wall shall in no case be less than 4 in.

**24. Protection.**—The reinforcement in columns and girders shall be protected by minimum thickness of 2 in. of concrete; in beams and walls by a minimum of 1½ in. in floor slabs by a minimum of ¾ in.; in footings by a minimum of 3 in.

## NEW YORK BUILDING CODE REQUIREMENTS

**Working Stresses.**—Reinforced concrete structures shall be so designated that the stresses in pounds per square inch shall not exceed the following:

| | |
|---|---|
| Extreme fibre stress on concrete in compression | 650 |
| Concrete in direct compression | 500 |
| Shearing stress in concrete when all diagonal tension is resisted by steel | 150 |
| Shearing stress in concrete when diagonal tension is not resisted by steel | 40 |
| Bond stress between concrete and plain reinforcement | 80 |
| Bond stress between concrete and approved deformed bars | 100 |
| Tensile stress in steel reinforcement | 16,000 |
| Tensile stress in cold drawn steel wire or fabric, 35 per cent of the elastic limit but not more than | 20,000 |

In continuous beams the extreme fiber stress on concrete in compression may be increased 15 per cent, adjacent to supports.

The ratio of the moduli of elasticity of 1 : 2 : 4 stone or gravel concrete and steel shall be taken as one to fifteen. The ratio of the moduli of elasticity of 1 : 1½ : 3 stone or gravel concrete and steel shall be taken as one to twelve.

**Slabs and Beams.** (*a*) *Thickness.*—Slabs shall not be less than 4 in. in thickness for floors and 3½ in. for roofs.

(*b*) *Tee-Beams.*—Where adequate bond between slab and web of beam is provided, the slab may be considered as an integral part of the beam provided its effective width shall not exceed on either side of the beam one-sixth of the span length of the beam nor be greater than six times the thickness of the slab on either side of the beam, the measurements being taken from edge of web.

(*c*) *Placing of Reinforcement.*—All reinforcement shall be accurately located and secured against displacement. The reinforcement for slabs shall not be spaced farther apart than two and one-half times the thickness of the slab.

(*d*) *Web Reinforcement.*—Members of web reinforcement shall be so designed as adequately to take up throughout their length all stresses not taken up by the concrete. They shall not be spaced to exceed three-fourths of the depth of the beam in that portion where the web stresses exceed the allowable value of concrete in shear. Web reinforcement, unless rigidly attached, shall be placed at right angles to the axis of the beam and carried around the tension members.

**Use of Fillers in Floor Construction.**—When hollow tile, concrete blocks or other acceptable fillers are used in any reinforced concrete floor construction, the reinforced concrete members of such floor construction shall be designed in accordance with the provisions of this article to take the entire loads, provided, however, that when the fillers do not exceed 60 per cent of the construction, not more than 2½ in. of concrete shall be required over the fillers.

**Columns.** (*a*) *With Longitudinal Reinforcements Only.*—In concrete columns, having not less than one-half nor more than 4 per cent of vertical reinforcement secured against displacement by ¼-in. steel ties placed not farther apart than 15 diameters of the vertical rods nor more than 12 in., the allowable load shall be 500 lb. per square inch on the concrete, plus 7,500 lb. on the vertical reinforcement.

(*b*) *With Longitudinal and Lateral Reinforcement.*—In concrete columns, having not less than one-half nor more than 2 per cent of hoops or spirals spaced not farther apart than one-sixth of the diameter of the enclosed column nor more than 3 in., and having not less than 1 nor more than 4 per cent of vertical reinforcement, the allowable load shall be 500 lb. per square inch on the effective area of the concrete, plus 7,500 lb. per square inch on the vertical reinforcement, plus a load per square inch on the effective area of the concrete equal to two times the percentage of lateral reinforcement multiplied by the tensile stress in the lateral reinforcement prescribed under "Working Stresses," the percentage of lateral reinforcement being the volume of the hoops or spirals divided by the volume of the enclosed concrete in a unit length of column. The hoops or spirals shall be rigidly secured to at least four verticals to insure uniform spacing.

(*c*) *Structural Steel and Concrete.*—In columns of structural steel, thoroughly encased in concrete not less than 4 in. thick and reinforced with not less than 1 per cent of steel, the allowable load shall be 16,000 lb. per square inch on the structural steel, the percentage of reinforcement being the volume of the reinforcing steel divided by the volume of the concrete enclosed by the reinforcing steel. Not more than one-half of the reinforcing steel shall be placed vertically. The reinforcing steel shall not be placed nearer than 1 in. to the structural steel or to the outer surface of the concrete. The ratio of length to least radius of gyration of structural steel section shall not exceed one hundred and twenty.

(*d*) *When Richer Concrete is Used.*—In concrete columns the compression on the concrete may be increased 20 per cent when the fine and coarse aggregates are carefully selected and the proportion of cement to total aggregate is increased to one part of cement to not more than four and one-half parts of aggregate, fine and coarse, either in the proportion of one part of cement, one and one-half parts of fine aggregate and three parts of coarse aggregate, or in such proportion as will secure the maximum density. In such cases, however, the compressive stress in the vertical steel shall not exceed 7,200 lb. per square inch.

(*e*) *Eccentric Loads.*—Bending stresses due to eccentric loads shall be provided for by increasing the section of concrete or steel until the maximum stress shall not exceed the allowable working stress.

(*f*) *Length.*—In columns, the ratio of length to least side or diameter shall not exceed fifteen, but in no case shall the least side or diameter be less than 12 in.

**Walls.**—Enclosure walls of reinforced concrete shall be securely anchored at all floors. The thickness shall not be less than one-twenty-fifth of the unsupported height, but in no case less than 8 in. The steel reinforcement, running both horizontally and vertically, shall be placed near both faces of the wall; the total weight of such reinforcement shall be not less than ½ lb. per square foot of wall.

**Protection of Reinforcement.**—The reinforcement in columns and girders shall be protected by a minimum of 2 in. of concrete; in beams and walls by a minimum of 1½ in.; in floor slabs by a minimum of 1 in.; and in footings by a minimum of 4 in. of concrete.

## Flat Slabs*

**Application.**—The rules governing the design of reinforced concrete flat slabs shall apply to such floors and roofs, consisting of three or more rows of slabs, without beams or girders, supported on columns, the construction being continuous over the columns and forming with them a monolithic structure.

**Compliance with Building Code.**—In the design of reinforced concrete flat slabs, the provisions of the preceding articles of the building code shall govern with respect to such matters as are specified therein.

**Assumptions.**—In calculations for the strength of reinforced concrete flat slabs, the following assumptions shall be made:

(*a*) A plane section before bending remains plane after bending.

(*b*) The modulus of elasticity of concrete in compression within the allowable working stresses is constant.

(*c*) The adhesion between concrete and reinforcement is perfect.

(*d*) The tensile strength of concrete is nil.

(*e*) Initial stress in the reinforcement due to contraction or expansion in the concrete is negligible.

**Stresses.**—(*a*) The allowable unit shear in reinforced concrete flat slabs on the $bd$ section around the perimeter of the column capital shall not exceed 120 lb. per square inch; and the allowable unit shearing stress on the $bjd$ section around the perimeter of the drop shall not exceed (60) lb. per square inch, provided that the reinforcement is so arranged or anchored that the stress may be fully developed for both positive and negative moments.

The extreme fibre stresses to be used in concrete in compression at the column head section shall not exceed 750 lb. per square inch.

**Columns.**—For columns supporting reinforced concrete flat slabs, the least dimension of any column shall be not less than one-fifteenth of the average span of any slabs supported by the columns; but in no case shall such least dimension of any interior column supporting a floor or roof be less than 16 in. when round, nor 14 in. when square; nor shall the least dimension of any exterior column be less than 14 in.

**Column Capital.**—Every reinforced concrete column supporting a flat slab shall be provided with a capital whose diameter is not less than 0.225 of the average span of any slabs supported by it. Such diameter shall be measured where the vertical thickness of the capital is at least 1½ in., and shall be the diameter of the inscribed circle in that horizontal plane. The slope of the capital considered effective below the point where its diameter is measured shall nowhere make an angle with vertical of more than 45°. In case a cap of less dimensions than hereinafter described as a drop, is placed above the column capital, the part of this cap enclosed within the lines of the column capital extended upwards to the bottom of the slab or drop at the slope of 45° may be considered as part of the column capital in determining the diameter for design purposes.

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* Adopted July 8, 1920.

**Drop.**—When a reinforced concrete flat slab is thicker in that portion adjacent to or surrounding the column, the thickened portion shall be known as a drop. The width of such drop when used, shall be determined by the shearing stress in the slab around the perimeter of the drop, but in no case shall the width be less than 0.33 of the average span of any slabs of which it forms a part. In computing the thickness of drop required by the negative moment on the column head section, the width of the drop only shall be considered as effective in resisting the compressive stress, but in no case shall the thickness of such drops be less than 0.33 of the thickness of the slab. Where drops are used over interior columns, corresponding drops shall be employed over exterior columns and shall extend to the one-sixth point of panel from the center of the column.

**Slab Thickness.**—The thickness of a reinforced concrete flat slab shall be not less than that derived by the formulae $t = 0.024L\sqrt{w} + 1\frac{1}{2}$ for slabs without drops, and $t = 0.02 L\sqrt{w} + 1$ for slabs with drops, in which $t$ is the thickness of the slab in inches, $L$ is the average span of the slab in feet, and $w$ is the total live- and dead-load in pounds per square foot; but in no case shall this thickness be less than one-thirty-second of the average span of the slab for floors, nor less than one-fortieth of the average span of the slab for roofs, nor less than 6 in. for floors nor less than 5 in. for roofs.

**Reinforcement.**—(*a*) In the calculation of moments at any section, all the reinforcing bars which cross that section may be used, provided that such bars extend far enough on each side of such section to develop the full amount of the stress at that section. The effective area of the reinforcement at any moment section shall be the sectional area of the bars crossing such section multiplied by the sine of the angle of such bars with the plane of the section. The distribution of the reinforcement of the several bands shall be arranged to fully provide for the intermediate moments at any section.

(*b*) Splices in bars may be made wherever convenient but preferably at points of minimum stress. The length of any splice shall be not less than 80 bar diameters and in no case less than 2 ft. The splicing of adjacent bars shall be avoided as far as possible. Slab bars which are lapped over the column, the sectional area of both being included in the calculation for negative moment, shall extend to the lines of inflection beyond the column center.

(*c*) When the reinforcement is arranged in bands, at least 50 per cent of the bars in any band shall be of a length not less than the distance center to center of columns measured rectangularly and diagonally; no bars used as positive reinforcement shall be of a length less than half the panel length plus 40 bar diameters for cross bands, or less than seven-tenths of the panel length plus 40 bar diameters for diagonal bands and no bars used as negative reinforcement shall be of a length less than half the panel length. All reinforcement framing perpendicular to the wall in exterior panels shall extend to the outer edge of the panel and shall be hooked or otherwise anchored.

(*d*) Adequate means shall be provided for properly maintaining all slab reinforcement in the position assumed by the computations.

**Line of Inflection.**—In the design of reinforced concrete flat slab construction, for the purpose of making calculations of the bending moments at sections other than defined in these rules, the line of inflection shall be considered as being located one-quarter the distance, center to center, of columns, rectangularly and diagonally, from center of columns for panels without drops, and three-tenths of such distance for panels with drops.

**Moment Sections.**—For the purpose of design of reinforced concrete flat slabs, that portion of the section across a panel, along a line midway between columns, which lies within the middle two quarters of the width of the panel shall be known as the inner section, and those portions of the section in the two outer quarters of the width of the panel shall be known as the outer sections. Of the section which follows a panel edge from column to column and which includes the quarter perimeters of the edges of the column capitals, that portion within the middle two quarters of the panel width shall be known as the mid section and the two remaining portions, each having a projected width equal to one-quarter of the panel width shall be known as the column head sections.

**Bending Moments.**—In the design of reinforced concrete flat slabs the following provisions with respect to bending moments shall be observed. In the moment expressions used:

$W$ is the total dead- and live-load on the panel under consideration, including the weight of drop whether a square, rectangle or parallelogram.

$W_1$ is the total live-load on the panel under consideration.

$L$ is the length of side of a square panel center to center of columns; or the average span of a rectangular panel which is the mean length of the two sides.

$n$ is the ratio of the greater to the less dimension of the panel.

$h$ is the unsupported length of a column in inches, measured from top of slab to base of capital.

$I$ is the moment of inertia of the reinforced concrete column section.

**A. Interior Square Panels.**—The numerical sum of the positive and negative moments shall be not less than $\frac{1}{17}WL$. A variation of plus or minus 5 per cent shall be permitted in the expression for the moment on any section, but in no case shall the sum of the negative moments be less than 66 per cent of the total moment, nor the sum of the positive moments be less than 34 per cent of the total moment for slabs with drops; nor shall the sum of the negative moments be less than 60 per cent of the total moment, nor the sum of the positive moments be less than 40 per cent of the total moment for slabs without drops.

In two-way systems, for slabs with drops, the negative moment resisted on two column head sections shall be $-\frac{1}{32}WL$; the negative moment on the mid section shall be $-\frac{1}{133}WL$; the positive moment on the two outer sections shall be $+\frac{1}{80}WL$ and the positive moment on the inner section shall be $+\frac{1}{133}WL$; and for slabs without drops, the negative moment resisted on two column head sections shall be $-\frac{1}{36}WL$, the negative moment on the mid section shall be $-\frac{1}{133}WL$, the positive moment on the two outer sections shall be $+\frac{1}{63}WL$ and the positive moment on the inner section shall be $+\frac{1}{133}WL$.

In four-way systems, the negative moments shall be as specified for two-way systems; the positive moment on the two outer sections shall be $+\frac{1}{100}WL$, and the positive moment on the inner section shall be $+\frac{1}{100}WL$ for slab with drops; and the positive moment on the two outer sections shall be $+\frac{1}{64}WL$, and the positive moment on the inner section shall be $+\frac{1}{100}WL$, for slabs without drops.

In three-way systems, the negative moment on the column head and mid sections and the positive moment on the two outer sections, shall be as specified for four-way systems. In the expression for the bending moments on the various sections, the length $L$ shall be assumed as the distance center to center of columns, and the load $W$ as the load on the panel parallelogram.

**B. Interior Rectangular Panels.**—When the ratio $n$ does not exceed 1.1, all computations shall be based on a square panel of a length equal to the average span, and the reinforcement shall be equally distributed in the short and long directions according to the bending moment coefficients specified for interior square panels.

When the ratio $n$ lies between 1.1 and 1.33, the bending moment coefficients specified for interior square panels shall be applied in the following manner:

(*a*) In two-way systems, the negative moments on the two column head sections and the mid section and the positive moment on the two outer sections and the inner section at right angles to the long direction shall be determined as for a square panel of a length equal to the greater dimension of the rectangular panel; and the corresponding moments on the sections at right angles to the short direction shall be determined as for a square panel of a length equal to the lesser dimension of the rectangular panel. In no case shall the amount of reinforcement in the short direction be less than two-thirds of that in the long direction. The load $W$ shall be taken as the load on the rectangular panel under consideration.

(*b*) In four-way systems, for the rectangular bands, the negative moment on the column head sections and the positive moment on the outer sections shall be determined in the same manner as indicated for the two-way systems.

For the diagonal bands, the negative moments on the column head and mid sections and the positive moment on the inner section shall be determined as for a square panel of a length equal to the average span of the rectangle. The load $W$ shall be taken as the load on the rectangular panel under consideration.

(*c*) In three-way systems, the negative and positive moments on the bands running parallel to the long direction shall be determined as for a square whose side is equal to the greater dimension; and the moments on the bands running parallel to the short direction shall be determined as for a square whose side is equal to the lesser dimension. The load $W$ shall be taken as the load on the parallelogram panel under consideration.

**C. Exterior Panels.**—The negative moments at the first interior row of columns and the positive moments at the center of the exterior panels on moment sections parallel to the wall, shall be increased 20 per cent over those specified above for interior panels. The negative moment on moment sections at the wall and parallel thereto shall be determined by the conditions of restraint, but the negative moment on the mid section shall never be considered less than 50 per cent and the negative moment on the column head section never less than 80 per cent of the corresponding moments at the first interior row of columns.

**D. Interior columns** shall be designed for the bending moments developed by unequally loaded panels, eccentric loading or uneven spacing of columns. The bending moment resulting from unequally loaded panels shall be considered as $\frac{1}{40}W_1L$, and shall be resisted by the columns immediately above and below the floor line under consideration in direct proportion to the values of their ratios of $I/h$.

**E. Wall columns** shall be designed to resist bending in the same manner as interior columns, except that $W$ shall be substituted for $W_1$ in the formula for the moment. The moment so computed may be reduced by the counter moment of the weight of the structure which projects beyond the center line of the wall columns.

**F. Roof columns** shall be designed to resist the total moment resulting from unequally loaded panels, as expressed by the formulae in paragraphs (*D*) and (*E*) of this rule.

**Walls and Openings.**—In the design and construction of reinforced concrete flat slabs, additional slab thickness, girders or beams shall be provided to carry any walls or concentrated loads in addition to the specified uniform live- and dead-loads. Such girders or beams shall be assumed to carry 20 per cent of the total live and dead panel load in addition to the wall load. Beams shall also be provided in case openings in the floor reduce the working strength of the slab below the prescribed carrying capacity.

**Special Panels.**—For structures having a width of less than three rows of slabs, or in which exterior drops, capitals or columns are omitted, or in which irregular or special panels are used, and for which the rules relating to the design of reinforced flat slabs do not directly apply, the computations in the analysis of the design of such panels, shall, when so required, be filed with the superintendent of buildings.

## CHICAGO BUILDING CODE REQUIREMENTS

**Ratio of Moduli of Elasticity—Adhesion—Bond.** (*a*) The calculations for the strength of reinforced concrete shall be based on the assumed ultimate compressive strength per square inch designated by the letter "*U*" given in the table below for the mixture to be used.

(*b*) The ratio designated by the letter "*R*" of the modulus of elasticity of steel to that of the different grades of concrete shall be taken in accordance with the following table:

| Mixture | *U* | *R* |
|---|---|---|
| 1 cement, 1 sand, 2 broken stone, gravel or slag........ | 2,900 | 10 |
| 1 cement, 1½ sand, 3 broken stone, gravel or slag...... | 2,400 | 12 |
| 1 cement, 2 sand, 4 broken stone, gravel or slag ........ | 2,000 | 15 |
| 1 cement, 2½ sand, 5 broken stone, gravel or slag ...... | 1,750 | 18 |
| 1 cement, 3 sand, 7 broken stone, gravel or slag........ | 1,500 | 20 |

**Unit Stresses for Steel and Concrete.** (*a*) The stresses in the concrete and the steel shall not exceed the following limits:

(*b*) Tensile stress in steel shall not exceed one-third of its elastic limits and shall not exceed 18,000 lb. per square inch.

(*c*) Shearing stress in steel shall not exceed 12,000 lb. per square inch.

(*d*) The compressive stress in steel shall not exceed the product of the compressive stress in the concrete multiplied by the elastic modulus of the steel and divided by the elastic modulus of the concrete.

(*e*) Direct compression in concrete shall be one-fifth of its ultimate strength. Bending in extreme fiber of concrete shall be thirty-five one-hundredths of the ultimate strength.

(*f*) Tension in concrete on diagonal plane shall be one-fiftieth of the ultimate compressive strength.

(*g*) For a concrete composed of one part of cement, two parts of sand and four parts of broken stone, the allowable unit stress for adhesion per square inch of surface of imbedment shall not exceed the following:

| | Pounds per sq. in. |
|---|---|
| On plain round or square bars of structural steel.................... | 70 |
| On plain round or square bars of high carbon steel.................. | 50 |
| On plain flat bars in which the ratio of the sides is not more than 2 to 1 . . | 50 |
| On twisted bars when the twisting is not less than one complete twist in 8 diameters .................................................. | 100 |

(*h*) For specially formed bars, the allowable unit stress for bond shall not exceed one-fourth of the ultimate bond strength of such bars without appreciable slip which shall be determined by tests made by the person, firm or corporation to the satisfaction of the Commissioner of Buildings, but provided that in no case shall such allowable unit stress exceed 100 lb. per square inch of the specially formed bars.

**Design for Slabs, Beams and Girders.**—Reinforced concrete slabs, beams and girders shall be designed in accordance with the following assumptions and requirements.

(*a*) The common theory of flexure shall be applied to beams and members resisting bending.

(*b*) The adhesion between the concrete and the steel shall be sufficient to make the two materials act together.

(*c*) The steel to take all the direct tensile stresses.

(*d*) The stress strain curve of concrete in compression is a straight line.

(*e*) The ratio of the moduli of elasticity of concrete to steel shall be as specified in the table in preceding article.

**Moments of External Forces.** (*a*) Beams, girders, floor or roof slabs and joists shall be calculated as supported, or with fixed ends, or with partly fixed ends, in accordance with the actual end conditions, the number of spans and the design.

(*b*) When calculated for ends partly fixed for intermediate spans with an equally distributed load where the adjacent spans are of approximately equal lengths:

Bending moment at center of spans shall not be less than that expressed in the formula $\frac{WL^2}{12}$ for intermediate spans and $\frac{WL^2}{10}$ for end spans.

(*c*) The moment over supports shall not be less than the formula $\frac{WL^2}{18}$ and the sum of the moments over one support and at the center of span shall be taken not less than the formula $\frac{WL^2}{6}$.

In the formula hereinabove given "*W*" is the load per lineal foot and "*L*" the length of span in feet.

(*d*) In case of concentrated or special loads the calculations shall be based on the critical condition of loading.

(*e*) For fully supported slabs, the free opening plus the depth, for continuous slabs, the distance between centers of supports, is to be taken as the span.

(*f*) Where the vertical shear, measured on the section of a beam or girder between the centers of action of the horizontal stresses, exceeds one-fiftieth of the ultimate direct compressive stress per square inch, web reinforcement shall be supplied sufficient to carry the excess. The web reinforcement shall extend from top to bottom of beam, and loop or connect to the horizontal reinforcement. The horizontal reinforcement carrying the direct stresses shall not be considered as web reinforcement.

(*g*) In no case, however, shall the vertical shear, measured as stated above, exceed one-fifteenth of the ultimate compression strength of the concrete.

(*h*) For T-beams the width of the stem only shall be used in calculating the above shear.

(*i*) When steel is used in the compression side of beams and girders, the rods shall be tied in accordance with requirements of vertical reinforced columns with stirrups connecting with the tension rods of the beams or girders.

(*j*) All reinforcing steel shall be accurately located in the forms and secured against displacement; and inspected by the representative of the architect or engineer in charge before any surrounding concrete be put in place. It shall be afterwards completely inclosed by the concrete, and such steel shall nowhere be nearer the surface of the concrete than 1½ inches for columns, 1½ inches for beams and girders, and ½ inch, but not less than the diameter of the bar, for slabs.

(*k*) The longitudinal steel in beams and girders shall be so disposed that there shall be a a thickness of concrete between the separate pieces of steel of not less than one and one-half times the maximum sectional dimension of the steel.

(*l*) For square slabs with two-way reinforcements the bending moment at the center of the slab shall be not less than that expressed in the formula $\frac{WL^2}{24}$ for intermediate spans, and $\frac{WL^2}{20}$ for end spans.

(*m*) The moment over supports shall not be less than the formula $\frac{WL^2}{36}$ and the sum of the moments over one support and at the center of the span shall be taken not less than the formula $\frac{WL^2}{12}$.

In which above formula "*W*" is the load per lineal foot and "*L*" the length of the span.

(*n*) For square or rectangular slabs, the distribution of the loads in the two directions, shall be inversely as the cubes of the two dimensions.

(*o*) Exposed metal of any kind will not be considered a factor in the strength of any part of any concrete structure, and the plaster finish applied over the metal shall not be deemed sufficient protection unless applied of sufficient thickness and so secured as to meet the approval of the Commissioner of Buildings.

(*p*) Shrinkage and thermal stresses shall be provided for by introduction of steel.

**Limiting Width of Flange in "T" Beams.**—(*a*) In the calculation of ribs, a portion of the floor slab may be assumed as acting in flexure in combination with the rib. The width of the slab so acting in flexure is to be governed by the shearing resistance between rib and slab, but limited to a width equal to one-third of the span length of the ribs between supports and also limited to a width of three-quarters of the distance from center to center between ribs.

(*b*) No part of the slab shall be considered as a portion of the rib, unless the slab and rib are cast at the same time.

(*c*) Where reinforced concrete girders support reinforced concrete beams, the portion of floor slab acting as flange to the girder must be reinforced with rods near the top, at right angles to the girder, to enable it to transmit local loads directly to the girder and not through the beams.

**Reinforced Concrete Columns—Limit of Length—Per cent of Reinforcement—Bending Moment in Columns—Tying Vertical Rods.**—(*a*) Reinforced concrete may be used for columns in which the concrete shall not be leaner than a 1:2:4 mixture and in which the ratio of length to least side or diameter does not exceed twelve, but in no case shall the cross section of the column be less than 64 sq. in. Longitudinal reinforcing rods must be tied together to effectively resist outward flexure at intervals of not more than twelve times least diameter of rod and not more than 18 in. When compression rods are not required, reinforcing rods shall be used, equivalent to not less than one-half of 1 per cent (0.005) of the cross sectional area of the column; provided, however, that the total sectional area of the reinforcing steel shall not be less than 1 sq. in., and that no rod or bar be of smaller diameter or least dimensions than ½-in. The area of reinforcing compression rods shall be limited to 3 per cent of cross sectional area of the column. Vertical reinforcing rods shall extend upward or downward into the column, above or below, lapping the reinforcement above or below enough to develop the stress in rod by the allowable unit for adhesion. When beams or girders are made monolithic with or rigidly attached to reinforced concrete columns, the latter shall be designed to resist a bending moment equal to the greatest possible unbalanced moment in the beams or girders at the columns, in addition to the direct loads for which the columns are designed.

(*b*) When the reinforcement consists of vertical bars and spiral hooping, the concrete may be stressed to one-fourth of its ultimate strength as given on page 270, provided, that the amount of vertical reinforcement be not less than the amount of the spiral reinforcement, nor greater than 8 per cent of the area within the hooping; that the percentage of spiral hooping be not less than one-half of 1 per cent nor greater than 1.5 per cent; that the pitch of the spiral hooping be uniform and not greater than one-tenth of the diameter of the column, nor greater than 3 in.; that the spiral be secured to the verticals at every intersection in such a manner as to insure the maintaining of its form and position, that the verticals be spaced so that their distance apart, measured on the circumference be not greater than 9 in., nor one-eighth the circumference of the column within the hooping. In such columns, the action of the hooping may be assumed to increase the resistance of the concrete equivalent to two and one-half times the amount of the spiral hooping figured as vertical reinforcement. No part of the concrete outside of the hooping shall be considered as a part of the effective column section.

**Structural Steel Columns.**—When the vertical reinforcement consists of a structural steel column of box shape, with lattice or batten plates of such a form as to permit its being filled with concrete, the concrete may be stressed to one-fourth of its ultimate strength as given in table on page 270, provided that no shape of less than 1 sq. in. section be used and that the spacing of the lacing or battens be not greater than the least width of the columns.

**Curtain Walls in Skeleton Construction Buildings.**—Buildings having a complete skeleton construction of steel or of reinforced concrete construction, or a combination of both, may have exterior walls of reinforced concrete 8 in. thick; provided, however, that such walls shall support only their own weight and that such walls shall have steel reinforcement of not less than three-tenths of 1 per cent in each direction, vertically and horizontally, the rods spaced not more than 12-in. centers and wired to each other at each intersection. All bars shall be lapped for a length sufficient to develop their full stress for the allowable unit stress for adhesion. Additional bars shall be set around openings, the verticals wired to the nearest horizontal bars, and the horizontal bars at top and bottom of openings shall be wired to the nearest vertical bars. The steel rods shall be combined with the concrete and placed where the combination will develop the greatest strength, and the rods shall be staggered or placed and secured so as to resist a pressure of 30 lb. per square foot, either from the exterior or from the interior on each and every square foot of each wall panel.

## Flat Slabs*

**1. Definitions.**—Flat slabs as understood by this ruling are reinforced concrete slabs, supported directly on reinforced columns with or without plates or capitals at the top, the whole construction being hingeless and monolithic without any visible beams or girders. The construction may be such as to admit the use of hollow panels in the ceiling or smooth ceiling with depressed panels in the floor.

**2.** The column capital shall be defined as the gradual flaring out of the top of the column without any marked offset.

**3.** The drop panel shall be defined as a square or rectangular depression around the column capital extending below the slab adjacent to it.

**4.** The panel length shall be defined as the distance c. to c. of columns of the side of a square panel, or the average distance c. to c. of columns of the long and short sides of a rectangular panel.

**5. Columns.**—The least dimension of any concrete column shall be not less than one-twelfth the panel length, nor one-twelfth the clear height of the column.

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* Went into effect Mar. 1, 1918.

**6. Slab Thickness.**—The minimum total thickness of the slab in inches shall be determined by the formula: $t = W^{\frac{1}{2}}/44$( = square root of $W$ divided by 44), where $t$ = total thickness of slab in inches, $W$ = total live-load and dead-load in pounds on the panel, measured c. to c. of columns.

**7.** In no case shall the thickness be less than $\frac{1}{32}$ of the panel length ($L/32$) for floors, nor $\frac{1}{40}$ of the panel length ($L/40$) for roofs ($L$ being the distance c. to c. of columns).

**8.** In no case shall the thickness of slab be less than 6 in. for floors or roofs.

**9. Column Capital.**—When used the diameter of the column capital shall be measured where its vertical thickness is at least $1\frac{1}{2}$ in. and shall be at least 0.225 of the panel length.

The slope of the column capital shall nowhere make an angle with the vertical of more than 45 deg. Special attention shall be given to the design of the column capital in considering eccentric loads, and the effect of wind upon the structure.

**10. Drop Panel.**—When used, the drop panel shall be square or circular for square panels and rectangular or elliptical for oblong panels.

**11.** The length of the drop shall not be less than one-third of the panel length ($L/3$) if square, and not less than one-third of the long or short side of the panel respectively, if rectangular.

**12.** The depth of the drop panel shall be determined by computing it as a beam, using the negative moment over the column capital specified elsewhere in this ruling.

**13.** In no case, however, shall the dimensions of the drop panel be less than required for punching shear along its perimeter, using the allowable unit shearing stresses specified below.

**14. Shearing Stresses.**—The allowable unit punching shear on the perimeter of the column capital shall be $\frac{3}{50}$ of the ultimate compressive strength of the concrete as given on page 270. The allowable unit shear on the perimeter of the drop panel shall be 0.03 of the ultimate compressive strength of the concrete. In computing shearing stress for the purpose of determining the resistance to diagonal tension the method specified by the ordinance shall be used.

**15. Panel Strips.**—For the purpose of establishing the bending moments and the resisting moments of a square panel, the panel shall be divided into strips known as strip $A$ and strip $B$. Strip $A$ shall include the reinforcement and slab in a width extending from the center line of the columns for a distance each side of this center line equal to one-quarter of the panel length. Strip $B$ shall include the reinforcement and slab in the half width remaining in the center of the panel. At right angles to these strips, the panel shall be divided into similar strips $A$ and $B$, having the same widths and relations to the center line of the columns as the above strips. These strips shall be for designing purposes only, and are not intended as the boundary lines of any bands of steel used.

**16.** These strips shall apply to the system of reinforcement in which the reinforcing bars are placed parallel and at right angles to the center line of the columns, hereinafter known as the two-way system, and also to the system of reinforcement in which the reinforcing bars are placed parallel, at right angles to and diagonal to the center line of the columns hereinafter known as the four-way system.

**17.** Any other system of reinforcement in which the reinforcing bars are placed in circular, concentric rings and radial bars, or systems with steel rods arranged in any manner whatsoever, shall comply with the requirements of either the two-way or the four-way system herein specified.

**18. Bending Moment Coefficients, Interior Panel, Two-way System.**—In panels where standard drops and column capitals are used as above specified, the negative bending moment, taken at a cross-section of each strip $A$ at the edge of the column capital or over it, shall be taken as $WL/30$.

**19.** The positive bending moment taken at a cross-section of each strip $A$ midway between column centers shall be taken as $WL/60$.

**20.** The positive bending moment taken at a cross-section of each strip $B$ in the middle of the panel shall be taken as $WL/120$.

**21.** The negative bending moment taken at a cross-section of each strip $B$ on the center line of the columns shall be taken as $WL/120$.

**22.** In the formulas hereinabove given $W$ = total live- and dead-load on the whole panel in pounds, $L$ = panel length, c. to c. of columns.

**23. Bending Moment Coefficients, Interior Panel, Four-way System.**—In panels where standard drops and column capitals are used as above specified, the negative bending moment, taken at a cross-section of each strip $A$ at the edge of column capital or over it, shall be taken as $WL/30$.

**24.** The positive bending moment, taken at a cross-section of each strip $A$, midway between column centers, shall be taken as $WL/80$.

**25.** The positive bending moment, taken at a cross-section of each strip $B$, taken in the middle of the panel, shall be taken as $WL/120$.

**26.** The negative bending moment, taken at a cross-section of each strip $B$ on the center line of the columns, shall be taken as $WL/120$.

**27. Bending Moment Coefficients, Wall Panels.**—Where wall panels with standard drops and capitals are carried by columns and girders built in walls, as in skeleton construction, the same coefficients shall be used as for an interior panel, except as follows: The positive bending moments on strips *A* and *B* midway between wall and first line of columns shall be increased 25 per cent.

**28.** Where wall panels are carried on new brick walls, these shall be laid in Portland cement mortar and shall be stiffened with pilasters as follows: If a 16-in. wall is used, it shall have a 4-in. pilaster. If a 12-in. wall is used, it shall have an 8-in. pilaster. The length of pilasters shall be not less than the diameter of the column, nor less than one-eighth of the distance between pilasters. The pilasters shall be located opposite the columns as nearly as practicable, and shall be corbeled out 4 in. at the top, starting at the level of the base of the column capital. Not less than 8-in. bearing shall be provided for the slab, the full length of wall.

The coefficients of bending moments required for these panels shall be the same as those for the interior panels except as provided herewith: The positive bending moments on strips *A* and *B* midway between the wall and first line of columns shall be increased 50 per cent.

**29.** Where wall panels are supported on old brick walls, there shall be columns with standard drops and capitals built against the wall, which shall be tied to the same in an approved manner, and at least an 8-in. bearing provided for the slab, the full length. Where this is impracticable, there shall be built a beam on the underside of slab adjacent to the wall between columns, strong enough to carry 25 per cent of the panel load.

The coefficients of bending moments for the two cases of slab support herein described shall be the same as those specified in Sect. 27 and Sect. 28 for skeleton and wall bearing condition, respectively.

**30.** Nothing specified above shall be construed as applying to a case of slabs merely resting on walls or ledges, without any condition of restraint. These shall be figured as in ordinary beam-and-girder construction specified in the ordinances.

**31. Bending Moment Coefficients, Wall and Interior Columns.**—Wall columns in skeleton construction shall be designed to resist a bending moment of $WL/60$ at floors and $WL/30$ at roof. The amount of steel required for this moment shall be independent of that required to carry the direct load. It shall be placed as near the surfaces of the column as practicable on the tension sides, and the rods shall be continuous in crossing from one side to another. The length of rods below the base of the capital and above the floor line shall be sufficient to develop their strength through bond, but not less than 40 diameters, nor less than one-third the clear height between the floor line and the base of the column capital.

**32.** The interior columns must be analyzed for the worst condition of unbalanced loading. It is the intention of this ruling to cover ordinary cases of eccentric loads on the columns by the requirement of Sect. 5. Where the minimum size of column therein specified is found insufficient, however, the effect of the resulting bending moment shall be properly divided between the adjoining slab and the columns above and below according to best principles of engineering, and the columns enlarged sufficiently to carry the load safely.

**33. Bending Moment Coefficients, Panels Without Drops, or Capitals, or Both.**—In square panels where no column capital or no depressions are used, the sum total of positive and negative bending moments shall be equal to that computed by the following formula:

$$B.M. = (WL/8)(1.53 - 4k + 4.18k^3)$$

where $B.M.$ = numerical sum of positive and negative bending moments, regardless of algebraic signs.
$W$ = total live- and dead-load on the whole panel.
$L$ = length of side of a square panel, c. to c. of columns.
$k$ = ratio of the radius of the column or column capital to panel length, $L$.

This total bending moment shall be divided between the positive and the negative moments in the same proportion as in the typical square panels for two-way or four-way systems specified above for interior and wall panels respectively.

**34. Point of Inflection.**—For the purpose of making the calculations of the bending moment at the sections away from the column capital, the point of inflection shall be considered as being one-quarter the distance c. to c. of columns, both crosswise and diagonally, from the center of the column.

**35. Tensile Stress in Steel and Compressive Stress in Concrete.**—The tensile stress in steel and the compressive stress in the concrete to resist the bending moment shall be calculated on the basis of the reinforcement and slab in the width included in a given strip, and according to the assumptions and requirements given in the first three articles on page 270. The steel shall be considered as being concentrated at the center of gravity of all the bands of steel in a given strip.

**36.** For the four-way system of reinforcement the amount of steel to resist the negative bending moment over the support in each strip *A* shall be taken as the sum of the areas of steel in one cross band and one diagonal band. The amount of steel to resist the positive bending moment of each strip *B* shall be considered as the area of the steel in a diagonal band. The amount of steel to resist the positive bending moment in each strip *A* shall be considered as the area of the steel in a cross band, and the amount of steel to resist the negative moment in each strip *B* shall be the steel included in the width of strip *B*.

**37.** For the two-way system of reinforcement the amount of steel to resist the bending moment in any strip shall be considered as the area of steel included in the width of the strip.

**38.** In both systems of reinforcement the compressive stress in the concrete in any strip shall be calculated by taking the area of steel considered for each strip and applying it in a beam formula based on the principles given in the article on "Design for Slabs, Beams and Girders" on page 270.

**39.** Where drop panels are used, the width of beam assumed to resist the compressive stresses over the column capital shall be the width of the drop.

**40.** The width of beam, where no drop panels are used, shall be the width of steel bands. Where this is found insufficient, the area shall be increased by introducing compression steel in the bottom of slab.

**41. Rectangular Panels.**—When the length of panel in either two-way or four-way system does not exceed the breadth by more than 5 per cent, all computations shall be based on a square panel whose side equals the mean of the length and breadth, and the steel equally distributed among the strips according to the coefficients above specified.

**42.** In no rectangular panel shall the length exceed the breadth by more than one-third of the latter.

**43. Rectangular Panels, Four-way System.**—In the four-way system of reinforcement, where length exceeds breadth by more than 5 per cent, the amount of steel required in strip *A*, long direction, both positive and negative, shall be the same as that required for the same strip in a square panel whose length is equal to the long side of the rectangular panel.

**44.** The amount of steel, strip *A*, short direction, positive and negative, shall be the same as that required for the same strip in a square panel, whose length is equal to the short side of the rectangular panel.

**45.** The amount of steel in strip *B*, positive and negative, shall be the same as that required for similar strip in a square panel whose length is equal to the mean of the long and the short side of the rectangular panel.

**46.** In no case shall the amount of steel in the short side be less than two-thirds of that required for the long side.

**47. Rectangular Panels, Two-way System.**—In the two-way system of reinforcement the amount of steel required for the positive and the negative moment of each strip *A* shall be determined in the same manner as indicated for the four-way system above.

**48.** The amount of steel in strip *B*, positive and negative, running in short direction, shall be equal to that required for the same strip in a square panel whose length equals the long side of the rectangular panel.

**49.** The amount of steel in strip *B*, long direction, positive and negative, shall be equal to that required for the same strip in a square panel, whose length equals the short side of the rectangular panel.

**50.** In no case shall the amount of steel in strip *B*, long direction, be less than two-thirds of that in the short direction.

**51. Walls and Openings.**—Girders and beams shall be constructed under walls, around openings and to carry concentrated loads.

**52. Spandrel Beams.**—The spandrel beams or girders shall, in addition to their own weight and the weight of the spandrel wall, be assumed to carry 20 per cent of the wall panel load uniformly distributed upon them.

**53. Placing of Steel.**—In order that the slab bars shall be maintained in the position shown in the design during the work of pouring the slab, spacers and supports shall be provided satisfactory to the Commissioner of Buildings. All bars shall be secured in place at intersections by wire or other metal fastenings. In no case shall the spacing of the bars exceed 9 in. The steel to resist the negative moment in each strip *B* shall extend one-quarter of the panel length beyond the center line of the columns in both directions.

**54.** Splices in bars may be made wherever convenient, but preferably at points of minimum stress. The length of splice beyond the center point, in each direction, shall not be less than 40 diameters of the bars, nor less than 2 ft. The splicing of adjacent bars shall be avoided as far as possible.

**55.** Slab bars which are lapped over the column, the sectional area of both being included in the calculations for negative moment, shall extend not less than 0.25 of the panel length for cross bands and 0.35 of the panel length for diagonal bands, beyond the column center.

**56. Computations.**—Complete computations of interior and wall panels and such other portions of the building as may be required by the Commissioner of Buildings shall be left in the office of the Commissioner of Buildings when plans are presented for approval.

**57. Test of Workmanship.**—The Commissioner of Buildings or his representative may choose any two adjacent panels in the building for the purpose of ascertaining the character of workmanship. The test shall not be made sooner than the time required for the cement to set thoroughly, nor less than 6 weeks after the concrete had been poured.

**58.** All deflections under test load shall be taken at the center of the slab, and shall be measured from the normal unloaded position of the slab. The two panels selected shall be uniformly loaded over their entire area with a load equal to the dead-load plus twice the live-load, thus obtaining twice the total design load. The load shall remain in place not less than 24 hr. If the total deflection in the center of the panel under the test load does not exceed $\frac{1}{800}$ of the panel length, the slab may be placarded to carry the full design live-load. If it exceeds this amount of deflection, and recovers not less than 80 per cent of the total deflection within 7 days after the load is removed, the slab may be placarded to carry the full design live-load. If the deflection exceeds the allowable amount above specified, and the recovery is less than 80 per cent in 7 days after the removal of the test load, other tests shall be made on the same or other panels, the results of which will determine the amount of live-load the slabs will be permitted to carry.

**59. General.**—The design and the execution of the work shall conform to the general provisions and the spirit of the Chicago Building Ordinances in points not covered by this Ruling and to the best engineering practice in general.

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